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Use of Exploratory Factor Analysis to Identify Factors Influencing Safety Climate in Two Work Environments

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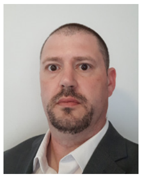
Safety Factor Analysis in Two Work Environments



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Introduction

Safety climate as used in this research was first formally defined by Zohar (1980) through a research study which encompassed 20 Israeli factories across a variety of industries as *"a summary of molar perceptions that employees share about their work environment"* (pg 96). The term safety climate has been conceptualized as employees' shared perceptions of how safety practices, policies, and procedures are implemented and prioritized, compared to other priorities such as productivity (Smith *et al.,* 2005). Safety climate can further be conceptualized as a view of the state of safety in the organization at a discrete point in time, which may change over time (Cheyne *et al.,* 1998; Cooper and Phillips, 2004; Neal, Griffin, and Hart, 2000; Guldenmund, 2000; Zohar, 1980, 2000, 2002a, 2002b).

The primary theoretical model underlying leading relationships of safety climate on safety outcomes is one in which safety climate affects employee behavior which in turn affects accidents and injuries (Payne *et al.,* 2009). Safety climate has been identified as an important predictor of a positive safety performance, with safety climate playing a mediating role in the relationship between safety leadership of the organization and the safety performance of the organization (Ajslev *et al.,* 2017; Barbaranelli, Petitta, and Probst, 2015; Feng *et al.,* 2014; Milijic *et al.,* 2013; Payne *et al.,* 2009; Smith *et al.,* 2006; Wu, Chen, and Li, 2008). Safety climate has demonstrated positive associations with safety compliance and participation (Clarke, 2006; Nahrgang, Morgeson, and Hofmann, 2008) and negative associations with workplace accidents and injuries (Stetzer and Hofmann, 1996; Probst, 2004). Kath, Magley, and Marmet (2010) also found that human aspects of safety climate, such as management attitudes and communication, also have an effect on organizational safety-related behaviors.

One way safety climate has been assessed is by using the Zohar Safety Climate Questionnaire (ZSCQ), or a derivative work thereof. Zohar's 1980 study established what has become a common way to assess safety climate: a questionnaire whose items (questions) measure a set of factors or constructs that reveal shared perceptions of the organization's safety climate. Zohar's original set of factors were 1) Importance of safety training, 2) Effects of required work pace on safety, 3) Status of safety committee, 4) Status of safety officer, 5) Effects of safe conduct on promotion, 6) Level of risk at work place, 7) Management attitudes toward safety, and 8) Effect of safe conduct on social status.

These factors clustered into five core constructs of safety climate: management commitment to safety, supervisory safety support, coworker (safety) support, employee (safety) participation, and competence level. Over the next 30 years and numerous research studies in a variety of industries (see Nahrgang, Morgeson, and Hofmann, 2008; Christian *et al.,* 2009 for meta-analyses), the original instrument had been modified numerous times depending on the focus and research questions of the implementing researcher. The questionnaire used in this paper was a derivative of the Zohar Safety Climate Questionnaire as developed by Zohar and Luria (2005), which comprised a 40-item survey and attempted to assess safety climate at both organizational-level and work group-level. A common method used to analyze the results of these safety climate surveys has been Exploratory Factor Analysis (EFA), which allows researchers to investigate concepts that are not easily measured directly by collapsing a large number of variables into a few interpretable underlying factors (Thompson, 2004). Following analytical methodology of previous studies, data for this study were analyzed using EFA, as well as additional associated tests to demonstrate analytical rigor.

Organizational climates have two important properties: level and strength. Climate level refers to the quality of a climate as positive or negative. Climate level corresponds to the mean of the individual group members' perceptions for whatever group is deemed relevant (e.g., workgroup, worksite, business division, organization, industry), and describes the average perception of safety climate by group members as "positive" or "negative". Climate strength refers to the variability of employees' perceptions

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of the policies, procedures, and practices regarding workplace safety (Beus, Bergman, and Payne, 2010). Climate level has been linked to safety-related outcomes such as safety compliance (Goldenhar, Williams, and Swanson, 2003; Neal and Griffin, 2006), workplace injuries (Probst, 2004; Zohar and Luria, 2004), near misses (Goldenhar, Williams, and Swanson, 2003; Probst, 2004), and automobile accidents (Morrow and Crum, 2004). Climate level does not provide sufficient information to allow for reliable predictive ability by itself, and does not adequately describe the extent to which a climate can influence organizational outcomes (Schneider, Salvaggio, and Subirats, 2002). The emphasis in this research is on safety climate level rather than strength.

Numerous studies have examined the relationship and correlation between positive safety climates and low incidence rates of injuries and incidents, and found that facilities and organizations that had positive safety climates had lower rates of incidents/accidents, lower worker's compensation payments, and increased participation by employees in the facility safety program (Ajslev *et al.,* 2017; Barbaranelli, Petitta, and Probst, 2015; Christian *et al.,* 2009; DeJoy *et al,* 2004; Feng *et al.,* 2014; Gillen *et al.,* 2002; Glendon and Litherland, 2001; Hale, 2009; Hofmann and Stetzer, 1998; Johnson, 2007; Milijic *et al.,* 2013; Nahrgang, Morgeson, and Hofmann, 2008; Payne *et al,* 2009; Reiman and Pietikainen, 2010, 2012; Saari, 1990, 2001; Salminen *et al.,* 1993; Smith *et al.,* 2006; Zohar, 1980, 2000, 2002a, b).

Payne *et al.* (2009) found that employees are likely to consider their own safety history as well as the overall safety history of the organization when evaluating safety climate. In organizations where incidents and injuries are infrequent, employees in the organization are likely to perceive that those employees directly involved in the event were the primary contributors to the cause of the event. If more incidents occur over time, employees begin to perceive that some single, underlying cause of these events exists, and being the common denominator, the organization will be perceived as the primary contributing factor of the incidents (Payne *et al.,* 2009).

Safety climate has been researched in the manufacturing sector (Christian *et al.,* 2006; Clarke, 2006; Zohar, 1980), the construction sector (Choudrhy *et al.,* 2009; Dedobbeleer and Béland, 1991; Fang, Chen, and Wong, 2006; Glendon and Litherland, 2001; Gillen *et al.,* 2002; Mohamed, 2002), as well as various other occupational sectors (Cox and Cheyne, 2000; Mearns, Whitaker, and Flin, 2003; Varonen and Mattila, 2000; Vinodkumar and Bhasi, 2009). Threats to the occupational safety and health in general industries include physical, chemical, biological (including infectious), ergonomic, and social hazards.

Although occupational sectors share similar hazard types, their unique operations present unique hazards, and while strong safety climates are associated with lower workplace injury rates, they rarely control for differences in industry hazards (Smith *et al.,* 2006). The peculiarities of safety climate in specific industries, and a method to measure it and use the results of analysis in meaningful ways is one of the goals of this research, and aligns with Zohar's (2010) reflection on 30 years of safety climate research where he noted that when a larger number of industry-specific safety climate scales are made available which offer a variety of concrete climate indicators, it would be possible to extrapolate underlying sense-making processes through which shared climate perceptions emerge (Zohar, 2010). Additionally, the identification of concrete climate indicators in each specific industry should offer opportunities for developing and testing hypotheses regarding processes underlying climate emergence (Zohar, 2010). The research study discussed in this paper used two existing data sets - Mosher (2011) and Simpson (2015), which were selected because they 1) were from under-represented industry segments, which would add to the body of knowledge regarding industry-specific safety climate scales, 2) the data sets were available in terms of convenience and had not been analyzed in the manner this research used, and 3) the primary point of the research was to determine the validity, of an established research instrument in measuring safety climate perceptions in industries it had not frequently been used in, not a test of the environments themselves, which had already been performed by previous researchers (see Mosher (2011) and Simpson (2015)). While it may seem awkward to think of university laboratories as an "industry", the researcher feels that the existing hazards in a university laboratory setting are strikingly similar to those of non-academic research facilities that perform laboratory work, in terms of physical hazards, chemical hazards, environmental concerns, safety training concerns, and adherence to rules and regulations. For ease of discussion in this paper, the university laboratory setting will be referred to as an "industry" or "industrial setting".

Perceptions of safety climate were measured at two levels based on previous research methodology (Zohar 2000, 2008; meta-analyses by Nahrgang, Morgeson, and Hofmann, 2008; Christian *et al.,* 2009; Mosher (2011), Mosher *et al.* (2013), and Simpson (2015)). These previous research studies suggest that although employees may informally communicate with their supervisor daily, communication with management is typically limited to more formal and less frequent exchanges, and as a result, perceptions of management and supervisors by employees may be quite different. Additionally, Zohar (2008) believes that while the management team may create and promote the organization's policies and procedures, it is the supervisors that actually implement and interpret these policies. In this research, employee perceptions of management were classified as organizational level, while employee perceptions of supervisor were described as group level. For the university laboratory data, supervisors are the laboratory supervisors (junior faculty members or post-doctoral researchers) while management is the P.I. (Principal Investigator) in charge of the laboratory or laboratories. In university laboratory settings, it is often junior faculty members or post-doctoral researchers who are billeted with supervisory duties of the day-to-day operations within the lab by junior graduate students, hence are considered to be supervisors, and as these supervisors report to the P.I. when appropriate or necessary, the P.I. is considered to be management.

Materials and Methods

This research seeks to identify the factors potentially influencing employee perceptions of safety at two levels of administration – organizational (management) and group (supervisory) in under-represented industry sectors of agricultural bulk-goods handling/storage and university research laboratories. The following research questions drove this research:

1. Are constructs previously identified in other industries also evident in an agricultural facility?
2. Are constructs previously identified in other industries also evident in university laboratories?
3. What similarities, if any, exist between the agricultural bulk commodity handling facility and university research laboratories in terms of the constructs identified through analysis?

Measures and Methodology

Two existing data sets were used for this study. Data from an agricultural bulk goods processing/handling facility consisted of responses from 187 participants on a 32-item survey, each item Likert-scaled from 1 to 5, with 1 indicating "Strongly Agree" and 5 indicating "Strongly Disagree". These data were collected from three separate facilities under the same company. Data from university research laboratories consisted of 109 responses on a 36-item survey. These data were from a random sample of 160 laboratories identified by Simpson (2015) having specific hazard types like biological, chemical, or radiological. These two data sets were utilized to validate the research instrument as compared to similar instruments which have been used in other industry sectors and shown to be an appropriate research instrument to measure safety climate. While each survey instrument asked questions specific to the work environment measured (Mosher, 2011; Simpson, 2015), both instruments trace their lineage back to the 40-item survey developed by Zohar and Luria (2005). Questions were modified slightly to account for differences in titles and work groups. Following previous studies' analytical methodology, each of these safety climate surveys' data was analyzed using Exploratory Factor Analysis in conjunction with additional tests to check fit statistics of the model.

Calculations and Variables

Following the analytical methodology used in previous studies examining safety climate through use of a survey instrument, each study's data was analyzed using Exploratory Factor Analysis to determine which, if any, latent factors were present. Given the small scale of each of these individual studies, each data set was examined to determine if the study had sampling adequacy to allow for the fitting of a structure through factor analysis. This was accomplished using Bartlett's Test for Correlation Adequacy as well as the Kaiser-Meyer-Olkin Factor Adequacy Test.

Each study's data was found to be adequate according to the Bartlett's Test and KMO test. After an initial fitting of the models, the outputs were examined to look for cross-loading variables, which were eliminated from further iterations of model fitting until cross-loading was eliminated. The final steps in the analysis for each of the data sets was the examination of each model's fit statistics (Tucker-Lewis Index and Comparative Fit Index) as well as a Reliability Analysis using Cronbach's Alpha to determine internal consistency or how closely related a set of items (survey questions in this example) are as a group.

Results

EXPLORATORY FACTOR ANALYSIS, AGRICULTURAL BULK COMMODITY STORAGE/HANDLING

With an N=187 on a 32-item survey, the first step of analysis was to determine the suitability of the data to be analyzed using exploratory factor analysis. Initial testing of this data set was performed by way of Bartlett's Test of Correlation Adequacy and the Kaiser-Meyer-Olkin Sampling Adequacy Test. Results of these tests are in Table 1.

Table 1. Adequacy Testing

Test	Value (test statistic)	P-value
Bartlett's Test of Sampling Adequacy	4843.683 (Chi-square)	0.000*
Kaiser-Meyer-Olkin Factor Adequacy	Overall MSA = 0.96**	N/A

* acceptable values of Bartlett's Test should be statistically significant at the $p<0.05$ level (Williams, Onsman, and Brown, 2010)
**KMO values between 0.8 and 1.0 indicate sampling is adequate (Williams, Onsman, and Brown, 2010)

Determination of number of potential factors was performed through a combination of Parallel Analysis, Kaiser's criterion, and Scree Plots, all three of which are methods for determining the number of components or factors to retain from factor analysis. According to Thompson and Daniel (1996): "simultaneous use of multiple decision rules is appropriate and often desirable" (page 200). The Parallel Analysis and Scree Plot for the Mosher (2011) data are shown in Figure 1, while the Kaiser's criterion data is shown in Table 2.

Figure 1. Parallel Analysis and Scree Plot for the Mosher (2011) data

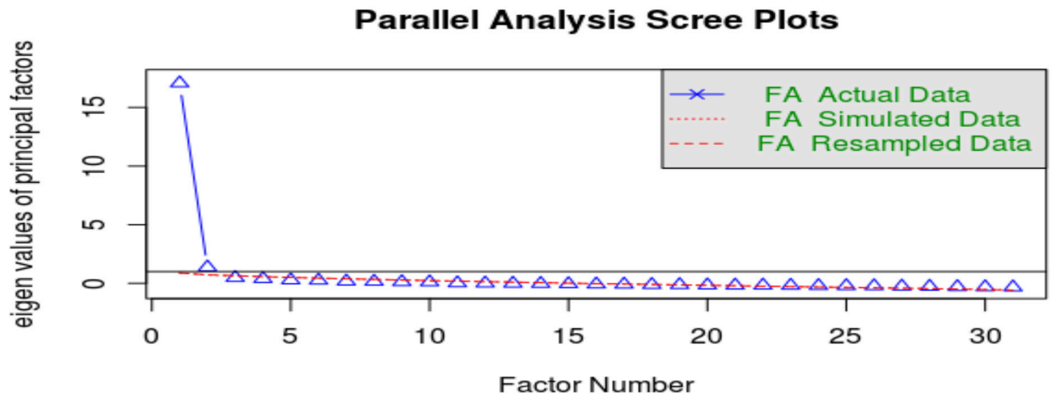


Table 2. Numbers of Indicated Factors via Kaiser's Criterion Values

Kaiser criterion value	Number of indicated factors
1.0*	2
0.7**	2

*Factors below the Eigenvalue of 1 should be dropped (Kaiser, 1960)
**Jollifee (1972) suggests that 0.7 is a more appropriate cutoff value

The Parallel Analysis/Scree Plot as well as Kaiser's criterion at both the 0.7 and 1.0 Eigenvalue indicate two principal factors, and primary fitting of the model was performed with two factors. Initial fit of the two-factor model showed cross-loading on three variables which were eliminated, and after their exclusion, the remaining 29 items loaded cleanly on the two factors, which were identified and named *Supervisor Involvement and Management Commitment*. Table 3 summarizes fit statistics used and results from the reliability analysis:

Table 3. Fit Statistics and Reliability Analysis

Index or Name	Value	Additional Info
Root Mean Square Residuals (RMSR)	0.04*	
Root Mean Square Error of Approximation (RMSEA)	0.061**	90% C.I. [0.047, 0.065]
Tucker-Lewis Index of Factoring Reliability (TLI)	0.939***	
Comparative Fit Index (CFI)	0.948[1]	
Cronbach's alpha (factor 1 – *Supervisor Involvement*)	0.96[2]	95% C.I. [0.95, 0.97]
Cronbach's alpha (factor 2 – *Management Commitment*)	0.95[3]	95% C.I. [0.94, 0.96]

*RMSR should be less than 0.08 (Browne and Cudeck, 1993) - ideally less than 0.05 (Stieger, 1990)
**A value of 0.06 or less is indicative of acceptable model fit (Hu and Bentler, 1999).
***A cut-off value of 0.90 or greater indicates acceptable model fit (Hu and Bentler, 1999)
[1] A cut-off value of 0.90 or greater indicates acceptable model fit (Hu and Bentler, 1999)
[2] a ≥ 0.90 indicates excellent internal consistency
[3] a ≥ 0.90 indicates excellent internal consistency

EXPLORATORY FACTOR ANALYSIS, UNIVERSITY RESEARCH LABORATORIES

With an N=109 on a 36-item survey, the first step of analysis was to determine the suitability of the data to be analyzed using exploratory factor analysis. Initial testing of this data set was performed by way of Bartlett's Test of Correlation Adequacy and the Kaiser-Meyer-Olkin Sampling Adequacy Test. Results of the tests are shown in Table 4.

Table 4. Adequacy Testing

Test	Value (test statistic)	P-value
Bartlett's Test of Sampling Adequacy	2773.188 (Chi-square)	1.50775e-265*
Kaiser-Meyer-Olkin Factor Adequacy	Overall MSA = 0.83**	N/A

* acceptable values of Bartlett's Test should be statistically significant at the p<0.05 level (Williams, Onsman, and Brown, 2010)
**KMO values between 0.8 and 1.0 indicate sampling is adequate (Williams, Onsman, and Brown, 2010)

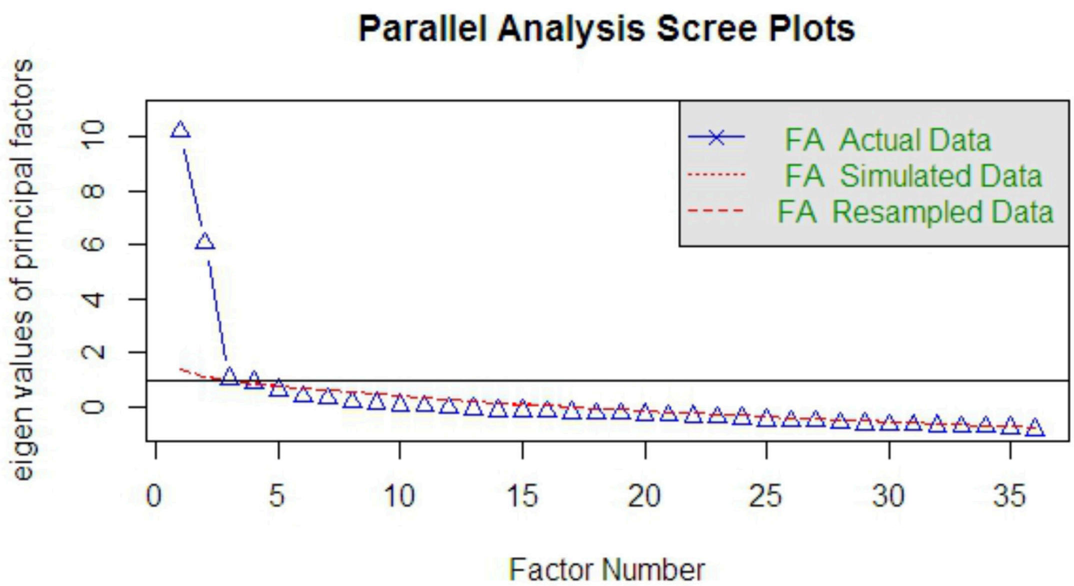
Determination of number of potential factors was performed using the same methodology as the agricultural data, through a combination of Parallel Analysis, Kaiser's criterion, and Scree Plots. Figure 2 represents the Scree Plot of this data set with Parallel Analysis shown as well, while Table 5 shows the Kaiser's criterion data.

Table 5. Numbers of Indicated Factors via Kaiser's Criterion Values

Kaiser criterion value	Number of indicated factors
1.0*	3
0.7**	4

*Factors below the Eigenvalue of 1 should be dropped (Kaiser, 1960)
**Jollifee (1972) suggests that 0.7 is a more appropriate cutoff value

Figure 2. Parallel Analysis Scree Plots



The information from the Parallel Analysis and Scree Plot indicate four principal factors while the Kaiser's criterion indicates that at the Eigenvalue of 1.0 only 3 principal factors are present versus four principal factors for the Eigenvalue of 0.7. Initial fit of the model for this data was performed with both three and four factors. The three-factor model had substantial cross-loading on the variables and after eliminating them from future iterations of model fitting, the resulting simple structure had very poor fit statistics. The four-factor model had much less cross-loading of variables compared to the three-factor model and the fit statistics were much better. Initial fit of the four-factor model showed cross-loading on fourteen variables which were eliminated, and after their exclusion, the remaining 22 items loaded cleanly on the four factors, which were identified and named *Supervisor Communication Reliability, Positive Safety Actions, Supervisor Dependability, Supervisor Consistency.* Initially, the substantial cross-loading among multiple factors was concerning and it was thought perhaps a simpler model might be appropriate, but models attempted with fewer than four factors would not converge, so the four factors indicated through the Parallel Analysis and Scree Plot were retained, and the cross-loading variables were eliminated. Table 6 summarizes the fit statistics used for this data set as well as the results from the reliability analysis.

Table 6. Fit Statistics and Reliability Analysis

Index or Name	Value	Additional Info
Root Mean Square Residuals (RMSR)	0.04*	
Root Mean Square Error of Approximation (RMSEA)	0.069**	90% C.I. [0.035, 0.077]
Tucker-Lewis Index of Factoring Reliability (TLI)	0.919***	
Comparative Fit Index (CFI)	0.949[1]	
Cronbach's alpha (factor 1 – *Sup. Comm. Reliability*)	0.89[2]	95% C.I. [0.86, 0.92]
Cronbach's alpha (factor 2 – *Positive Safety Actions*)	0.90[3]	95% C.I. [0.87, 0.93]
Cronbach's alpha (factor 3 – *Supervisor Dependability*)	0.61[4]	95% C.I. [0.47, 0.76]
Cronbach's alpha (factor 4 – *Supervisor Consistency*)	0.77[5]	95% C.I. [0.69, 0.84]

*RMSR should be less than 0.08 (Browne and Cudeck, 1993) - ideally less than 0.05 (Stieger, 1990)
**A value of 0.06 or less is indicative of acceptable model fit (Hu and Bentler, 1999).
***A cut-off value of 0.90 or greater indicates acceptable model fit (Hu and Bentler, 1999)
[1] A cut-off value of 0.90 or greater indicates acceptable model fit (Hu and Bentler, 1999)
[2] a ≥ 0.90 indicates excellent internal consistency
[3] a ≥ 0.90 indicates excellent internal consistency
[4] a ≥ 0.60 indicates questionable internal consistency
[5] a ≥ 0.70 indicates acceptable internal consistency

Through the statistical analyses performed, a number of potential factors were identified. These factors are presented here in the format of ---> **Factor Name:** *Source:* Researcher's definition of factor based on which ZSCQ questions corresponded (loaded) on a particular factor.

Supervisor Involvement – *agricultural bulk commodity storage/handling* – To what extent/to what degree does the relationship between an employee and his/her supervisor and that supervisor's active role in workplace safety affect perception of safety climate?

Management Commitment – *agricultural bulk commodity storage/handling* – To what extent/to what degree does the perception by employees of management's commitment to improving safety in the workplace affect perception of safety climate?

Supervisor Communication Reliability – *university research laboratories* – To what extent/to what degree does the perception that a supervisor communicates in an open, honest, and consistent manner to his/her employees affect perceptions of safety climate?

Positive Safety Actions – *university research laboratories* – To what degree/to what extent do things like being provided power to correct safety concerns, addressing safety concerns in a timely manner and following up on corrective actions, and emphasizing safety regardless of production/research deadlines affect perception of safety climate?

Supervisor Dependability – *university research laboratories* – To what degree/to what extent do actions of a supervisor such as following through on commitments and sharing relevant information with his/her subordinates affect perception of safety climate?
Supervisor Consistency – *university research laboratories* – To what degree/to what extent do perceptions of the consistency of emotions or actions of a supervisor by his/her employees affect perception of safety climate?

The identified factors correspond to the survey questions in a similar way as previous research. With regards to the factors identified in the agricultural bulk commodity storage/handling data from the Mosher (2011) data, the factors revealed in this study correspond to the two-level assessment of safety climate perceptions in the Zohar and Luria (2005) study. This indicates that the assessment tool used in the Mosher (2011, Mosher *et al,* 2013) study is a valid instrument for the assessment of safety climate perceptions in the agricultural bulk commodity storage/handling occupational sector. Also indicated is that both organizational-level (top management's commitment to safety or the priority of safety over competing operational goals such as production speed and costs) and group-level (interaction modes between supervisors and group members by which supervisors can indicate the priority of safety versus competing goals such as production speed or schedules) influence overall safety climate perceptions in this industry. With regard to research question 1 – *Are the previously identified constructs of the ZSCQ evident in a bulk commodity handling facility?* - with both organizational-level and group-level constructs revealed during the factor analysis of the agricultural bulk commodity storage/handling facility data, the research question can be answered in the affirmative.

The factors identified in the university research laboratories from the Simpson (2015) study also correspond to the two-level assessment of safety climate perceptions in the Zohar and Luria (2005) study. Indicating that the assessment tool used in the Simpson (2015) study is a valid instrument for the assessment of safety climate perceptions in university research laboratories, also indicated is that both organizational-level and group-level influence overall safety climate perceptions in this industry. Further, the identified factors from university research laboratories appear to have parallels with the constructs identified in the Zohar (1980) study as well. Regarding research question 2 – *Are the previously identified constructs of the ZSCQ evident in university research laboratories?* - with both organizational-level and group-level constructs revealed during the factor analysis of the university research laboratory data, the research question can be answered in the affirmative.

Research question 3 – *What similarities, if any, exist between the agricultural bulk commodity handling facility and university research laboratories?* - can be answered in two dimensions. Firstly, for both industry segments investigated in this research, the previously identified constructs related to both organizational-level and group-level are also identified in both the agricultural bulk commodity sector and university research laboratories. Secondly, the university research laboratory data revealed three distinct factors under the organizational-level construct – *Supervisor Communication Reliability, Supervisor Dependability,* and *Supervisor Consistency,* which indicates that for workers and supervisors in university research laboratories, the attitude of, actions of, and communication of management-level persons influences safety climate perceptions of those who work under them in the laboratory/ies.

Potential implications from this study provide information on factors influencing safety climate that are specific to two work environments, but also raises additional questions related to safety outcomes in the workplace:

Factor 1 – Supervisor Involvement – do supervisory personnel in the facility play an active role in the safety and health programs, and does the relationship a supervisor has with his/her subordinates foster active participation in safety programs? Is the supervisor's role a positive or negative influence on safety outcomes in the organization or work group?

Factor 2 – Management Commitment – do senior management personnel in the facility demonstrate through words and/or deeds their commitment to improving safety and health in the workplace and do workers recognize and acknowledge this commitment? What influence do these actions have on worker perceptions and does the management play a positive or negative role in organizational safety outcomes?

Factor 3 – Supervisor Communication Reliability – do supervisory personnel in the workplace communicate in a forthcoming, honest, open, and consistent manner to all personnel, and especially to workers in regard to safety in the workplace? If so, how much of an influence do these positive actions have on safety perceptions of employees?

Factor 4 – Positive Safety Actions – are supervisory and management personnel in the facility acting/behaving in ways which foster positive safety climate? For example, are supervisory and management personnel providing subordinates the power to correct safety concerns when identified? Are safety concerns addressed in a timely manner? Is follow-up on corrective actions done and on a consistent basis? Is safety emphasized regardless of production schedules or deadlines? What role do positive actions by supervisors and management play in worker safety perceptions and attitudes?

Factor 5 – Supervisor Dependability – Are supervisory personnel in the facility following through on commitments they have made, and are supervisors sharing relevant information with his/her subordinates? What positive impacts does supervisor dependability have on worker safety perceptions? What might be the potential damage from negative supervisory dependability?

Factor 6 – Supervisor Consistency – Are supervisory personnel in the facility consistent in their emotional states or are they volatile? Are their actions consistent? Do supervisors attempt to treat subordinates equally, or is there favoritism? If not, how does this influence worker safety perceptions and attitudes?

For firms that seriously attempt to address the questions posed in these points may help to identify gaps where the safety practitioner can focus improvement efforts or intervention in his or her facility. The factors identified during the course of this analysis have also been identified in previous research studies. This result is not unexpected given the number of investigations performed in the variety of industries over the last 40 years. Yet, this research study has uncovered factors that potentially influence safety climate perceptions in two under-researched industries. Further, the magnitude of the potential influence is still unknown.

The results of the statistical analyses performed on the two data sets used in this study provide evidence to support that the existing safety climate research instrument is a suitable and valid measure of safety climate in the agricultural bulk commodity storage/handling industry as well as with university research laboratories. Both data sets were found to be adequate for the fitting of a model, and a model was able to be fit to the data. While the factors identified through the factor analysis of the university research laboratory data produced fit statistics that are below what would normally be desirable, the low number of respondents to the survey instrument undoubtedly played a role in these results. Reliability analysis for each data set produced values which ranged from questionable to excellent, with most values in the excellent value range. However, the values of the fit statistics do not give information regarding the strength of a factor's influence on safety climate perceptions.

Conclusions

Safety climate research has traditionally been dominated by a quantitative methodology and the need to use factor analyses to reveal the underlying structure of the concept. (Kongsvik, Almklov, and Fenstad, 2010). Previous research studies of safety climate have identified potential factors that affect safety climate perceptions, and the research study outlined in this paper continues this tradition. Smith *et al.* (2006) theorized that factors such as workers' perception of the hazards and risks in the workplace are likely an important factor influencing the perception of safety climate, and those perceptions of safety climate are likely related to perceptions of the company's safety record, both within the industry and to those outside the industry. Based on the analysis of data sets described in this paper, factors which potentially affect perception of safety climate have been identified and warrant further investigation.

Further, by utilizing data from industry segments which have historically received little research in the literature, the goal was to determine if the factors identified from these industry segments correspond to previously identified factors in other industries, or if there are new factors. The factors identified appear to correspond to factors uncovered in other industry segments which have had more frequent study such as manufacturing (Christian *et al.,* 2006; Clarke, 2006; Zohar, 1980), construction (Choudrhy *et al.,* 2009; Dedobbeleer and Béland, 1991; Fang, Chen, and Wong, 2006; Glendon and Litherland, 2001; Gillen *et al.,* 2001; Mohamed, 2002), and health care (Agnew, Flin, and Mearns, 2013; Flin, 2007; Ginsburg *et al.,* 2009). While acknowledging that workplaces are singular in certain aspects and the safety climate of one workplace might not be the same as that of another, each workplace has, at its most fundamental level, a commonality – the worker. While there is a case to be made that there are discrete differences between workers based on a number of factors, on a fundamental level, they have many similarities. Workers go to work, interact with other workers, are involved with the safety program of their workplace, follow the directives of their supervisors and upper management, and are part of the overall safety climate of the workplace. Given the role safety climate plays in workplace incidents, it is important to identify variables that foster a positive safety climate in order to further our understanding of the development of safety climate and our ability to enhance it (Beus *et al.,* 2010).

This research study had a number of limitations which are noted as follows:

1. The data used in this research study were preexisting and were seven years old for the Mosher (2011) data, two years old for the Simpson (2015) data. While the age of the data had no bearing on the results of the statistical analysis and the results validate the safety climate survey instrument, there is a possibility that the current safety climate in the facilities/industries sampled is different than what was revealed by analyzing the existing data.

2. Each data set had a response rate which is far below the idealized 20:1 or 30:1 for performing Exploratory Factor Analysis. While this study was able to fit models to each data set and those models produced acceptable fit statistics, a larger pool of data would likely increase the confidence of the researcher concerning the results of analysis.

3. This study identified factors which are thought to influence safety climate perceptions, however there was no test-retest performed to compare results to see if in fact the same or similar factors were identified in subsequent sampling. In conjunction with this study's data being from preexisting data sets, the identified factors may only be valid at the time the initial sample was taken.

While the research in this study has identified factors which influence safety climate perceptions in the industries studied, what is still unknown is to what degree or extent these factors influence. A possible avenue for future research would be the addition of a qualitative research study which could gather information from employees in the form of narrative collection or personal interviews, and to analyze the results from this qualitative study to determine if new information regarding safety climate perceptions can be learned and extended to further benefit the safety and health of safety-sensitive workplaces.

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