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A qualitative and quantitative examination of factors underlying safety climate

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by

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This dissertation, while the conclusion of my graduate studies, stands only as a demonstration of my ability to conceptualize, carry out, and describe a research study. In the last ten years since I first began my PhD program, my life has undergone a number of drastic, painful, and indelible changes – and I learned more from those experiences than I could have in a hundred PhD programs. Whether info from this document is published in peer-reviewed journals or if it fades into complete obscurity, I will always retain the life lessons I learned along this decade-long journey.

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ABSTRACT

The assessment of safety climate in the workplace has been a recurring research topic over the last four decades. Often assessed through the collection of Likert-scaled survey instrument data and subsequent data analysis, previous research studies have indicated that there are potentially a number of latent factors which account for safety climate perceptions of the studied population that may not be revealed through survey data collection. Lacking in the body of research is a mixed-methods approach that can substantiate the level of influence these identified factors have on safety climate perceptions.

The research in this dissertation sought to identify factors influencing safety climate, and combined with additional data collection in the form of personal narratives, these identified factors were examined to determine the degree by which the identified factors influence and characterize personal and group safety climate perceptions. This was accomplished through use of a Constructivist Grounded Theory approach to the research question, which allows for continual data collection as well as proceeding with research without the need to formulate a testable hypothesis before investigation begins.

NOMENCLATURE

ANOVA	Analysis of Variance
BLS	Bureau of Labor Statistics
CFI	Comparative Fit Index
CGT	Constructivist Grounded Theory
EFA	Exploratory Factor Analysis
GT	Grounded Theory
ICGT	Informed Constructivist Grounded Theory
KMO	Kaiser-Meyer-Olkin
LTI	Long-Term Injury
MSA	Mean Sampling Adequacy
OSH	Occupational Safety and Health
OSHP&P	Occupational Safety and Health Policies and Programs
POS	Perceived Organizational Support
RMSEA	Root Mean Squared Error of Approximation
RMSR	Root Mean Squared Residuals
TLI	Tucker-Lewis Index
ZSCQ	Zohar Safety Climate Questionnaire

CHAPTER 1. INTRODUCTION TO RESEARCH

Occupational safety continues to be a challenge for managers, supervisors, and workers in all areas of the workforce. According to data from the Bureau of Labor Statistics (2016), there were 5,190 fatal workplace accidents in the United States in 2016, with more than 2.9 million non-fatal workplace injuries (Bureau of Labor Statistics, 2016).

Many Occupational Safety and Health (OSH) initiatives are evaluated primarily with lagging metrics, such as fatality and injury rates, despite the growing research that these measures are less useful in driving continuous improvement efforts in safety (Hubbard, 2004; Agnew, Flin, and Mearns, 2013). Leading indicators, on the other hand, offer promise as an improved gauge of OSH activity by providing early warning signs of potential failure, enabling organizations to identify and correct deficiencies before they trigger injuries and damage (Sinelnikov, Inouye, and Kerper, 2015). Studies in 2010 and 2012 by Reiman and Pietikäinen, respectively, state that the most effective leading indicators are those that monitor the capacity of an organization to perform safely (e.g. testing of systems and equipment, employee hazard awareness) and drive the safety management system toward continual improvement (e.g. safety management leadership, contingency planning).

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 (Wu, Chen, and Li, 2008). 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. According to Wu, Chen, and Li, (2008), safety climate measures perceptions of the CEOs' and managers' safety commitment and action by employees, which influence the safety organization and management, safety equipment and measures, and accident investigations. Kath, Magley, and Marmet (2010) used work by Whitener *et al*., (1998) to theorize the following about management attitudes and safety:

1. Management attitudes toward safety include employees' perception that their supervisors view safety as important; safety communication from the employees to the management reflects the comfort subordinates feel in bringing safety-related information to their superiors.
2. Managers who are accurate and adequate in their safety communications keep the lines of communication open, encouraging trust among their employees.
3. When managers emphasize the importance of safety to their workers, they are outwardly communicating their perceptions about the issue. In doing so, they are expressing their concern for the well-being of the employees.

Hence, if employees truly believe that their managers value safety and note their managers' concern for them, increased organizational trust may result (Kath, Magley, and Marmet, 2010). In other words, trust is developed by working in an environment in which management deems safety to be important and communications surrounding safety are welcomed. Subsequently, the trust influences employees' satisfaction with their jobs and desire to remain a member of the organization (Kath, Magley, and Marmet 2010). Clarke (2006) demonstrated a positive correlation between safety climate and increased safety participation and compliance, but the finding was not universal across the industry segments Clarke examined in his meta-analysis. Michael *et al*., (2006) assert that the positive correlation between safety climate and safety participation/compliance were insufficient in explaining organizational outcomes. Several previous studies have examined the effects of safety leadership on safety behavior (O'Dea and Flin, 2001; Neal, Griffin and Hart, 2000, Neal and Griffin, 2006). Bryden (2002) identified a number of critical behaviors for safety, namely: articulating an attainable vision of future safety performance; demonstrating personal commitment to safety symbolically; engaging everyone with relevant experience in decision-making; and being clear and transparent when dealing with safety issues.

Purpose of Research

Missing from previous research is the examination of safety climate perceptions, particularly in agricultural bulk commodity handling/storage facilities as well as in university research laboratories, from a mixed-methods approach to the methodology. The research proposed in this document is an attempt to partially bridge this knowledge gap in the existing body of research through: 1) quantitative analysis of safety climate survey data and employee self-assessments, 2) development of questions for narrative inquiry to employees derived from the results of the quantitative analyses, and 3) the examination of both quantitative and qualitative data in a mixed-methods proof of concept study utilizing informed constructivist Grounded Theory.

To answer the research questions related to perceptions of safety climate in an occupational workplace setting, data collected from prior studies utilizing a survey instrument (the Zohar Safety Climate Questionnaire (Zohar and Luria, 2005; Johnson, 2007)) will be statistically analyzed and those results compared to other previous published research studies to determine if the data collected in the agricultural and research laboratory fields agree with those data collected in other occupational fields like manufacturing, telecommunication, transportation, oil and gas exploration, etc. The Zohar Safety Climate Questionnaire (ZSCQ) is a 40-item instrument developed by Zohar and Luria in 2005, using preliminary work from Zohar's 1980 work in the area of safety climate and distributed across 20 Israeli factories across a variety of industries in an attempt to measure those factors which affect “safety climate”, which Zohar defined as “*a summary of molar perceptions that employees share about their work environment*” (Zohar 1980, pg 96). This study established what has become the 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
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.

Specifically, previously collected data from an agricultural bulk commodity handling/storage facility and university research laboratories will be analyzed using accepted statistical methods to compare the results with other published research studies in this field in an attempt to validate the research instrument used to collect the data. This research instrument has had success measuring safety climate perceptions in a variety of occupational sectors. For this reason, it is expected that similar results will be seen in the two occupational sectors examined in this research, thereby validating the research instrument as appropriate to accurately measure safety climate across an ever-widening variety of industry sectors. From this validation of research instrument by way of identifying latent factors that explain safety climate scores as well as identifying statistically significant self-assessment factors which also "explain" safety climate scores, a series of questions derived from the identified factors/variables will be developed for the collecting of personal narratives. These narratives, once collected, coded, and analyzed, will serve as the qualitative portion of the mixed-methods portion of the research. An informed, constructivist, Grounded Theory will be used/developed both as a methodology and as theory, which will combine all the data collected during this study. At the conclusion of this study, the analysis of the qualitative portion of data will either: 1) confirm or agree with the quantitative data analysis (Explanatory Factor Analysis), 2) fail to confirm or countermand the quantitative data analysis (Explanatory Factor Analysis) or, 3) reveal an aspect of safety climate that was not identified in the quantitative instrument (see Appendix A, B). Finally, the informed constructivist Grounded Theory will either: 1) Demonstrate to be an appropriate methodology to examine safety climate from a mixed-methods approach or, 2) Demonstrate to be an inappropriate methodology to examine safety climate from a mixed-methods approach.

At the conclusion of this research it is anticipated that the combination of both quantitative and qualitative data sources through use of an informed constructivist grounded theory will result in a more thorough understanding of worker perceptions of safety climate and how those perceptions effect how employees interact with safety in the workplace.

Research Questions

The study will be guided by the following research questions:

1. Is the existing safety climate research instrument (ZSCQ) an accurate measure of safety climate in the occupational industries of interest to this research?

    1A. Are the previously identified constructs of the ZSCQ evident in a bulk commodity handling facility?

    1B. Are the previously identified constructs of the ZSCQ evident in university research laboratories?

    1C. What differences, if any, exist between the agricultural bulk commodity handling facility and university research laboratories?

2. What role do demographic factors and qualitative aspects such as job satisfaction, and attitude about pay and promotions play in overall safety climate?

    2A. Do demographic factors such as age, job tenure, and pay play a significant and positive role in safety climate (at the organizational and work group levels) in the two work environments of this study's focus?

    2B. Does job satisfaction play a significant and positive role in safety climate at organizational and work group levels in the two work environments of this study's focus?

    2C. Does pay satisfaction play a significant and positive role in safety climate at organizational and work group levels in two work environments of this study's focus?

3. Are there gaps in data collection that could be addressed by the development and deployment of a qualitative framework like narrative inquiry?

3A. What constructs are not effectively measured by quantitative safety climate survey instruments?

3B. What constructs emerge from literature and interviews/narrative collection?

3C. Can an informed constructivist grounded theory identify and explain previously unidentified constructs of safety climate?

Measurement and Methodology

The data utilized in this research study were sourced from two previous research studies which utilized a research instrument based on the Zohar Safety Climate Questionnaire (ZSCQ), the Organization and Group Level Safety Climate instrument (Zohar and Luria, 2005). The instrument consisted of 32 items for Mosher (2011) and 40 items for Simpson (2015) and surveyed employees on two levels: organizational (management) and group (supervisory). Items were scored on a 5-point scale (1 = Strongly agree; 2 = Agree; 3 = Neutral; 4 = Disagree; 5 = Strongly disagree). Examples of items used include “top management react quickly to solve problems when told about safety hazards” and “my supervisor emphasizes safety procedures when we are working under pressure”. Additional data was collected via Likert-scaled survey which gathered demographic information as well as data regarding personal ratings of job satisfaction and fairness of pay. These studies were conducted at Agricultural Bulk Goods Handling facilities in Iowa (Mosher, 2011), and among research laboratories at Iowa State University (Simpson, 2015). These previous studies were utilized because when initially undertaken, the principal investigators analyzed the data through different methods than needed for this current research study, and therefore the data collected would be suitable for use as part of the quantitative analysis used in this research study. Following the methodological approach of previous research studies using survey instruments based wholly or in part upon the ZSCQ, an Exploratory Factor Analysis (EFA) was used to analyze the data used in this study, after tests for sampling adequacy and parallel analysis had been performed.

For each of the two data sets used in this study, after the data was imported for analysis and the independent variables defined, the Bartlett's Test of Sphericity was performed. Bartlett's Test for Correlation Adequacy (aka Bartlett's Test of Sphericity) is a way to test the assumption that there are at least some correlations among the variables so that coherent factors can be identified. It is desirable to have some degree of collinearity among the variables but not an extreme degree or singularity among the variables (Schreiber, Nora, and Stage, 2006). The test statistic from this test should be statistically significant at the $p<0.05$ value to be deemed acceptable (Williams, Onsman, and Brown, 2010). The Bartlett's test checks if the observed correlation matrix diverges significantly from the identity matrix (theoretical matrix under H0: the variables are orthogonal). In order to measure the overall relation between the variables, the determinant of the correlation matrix is computed |R|. Under H0, |R| = 1; if the variables are highly correlated, $||R| \approx 0$. The Bartlett's test statistic indicates to what extent we deviate from the reference situation |R| = 1, and uses the following formula:

Formula 1. Bartlett's Test of Spherecity

$$\chi^2 = -\left(n - 1 - \frac{2p+5}{6}\right) x \ln\left(|R|\right)$$

Under H0, it follows a χ^2 distribution with a [p x (p-1) / 2] degree of freedom. Each of the prior studies which lent their data to this research study had a "low" ratio of survey items to respondents (< 20:1), yet was "acceptable" at ~6:1, therefore the Bartlett's Test was performed to determine if Exploratory Factor Analysis could proceed. For each of the two data sets used, the Bartlett's Test statistic was significant at the ($p<0.05$) level, indicating the factor analysis could be undertaken.

Additional testing of sampling adequacy was performed by way of the Kaiser-Meyer-Olkin (KMO) Test for Sampling Adequacy. Kaiser-Meyer-Olkin (KMO) is a measure of how well suited a data set is for Factor Analysis. There is disagreement in the literature regarding what constitutes an acceptable sample size for factor analysis as well as an acceptable ratio of participant-to-variables. Often termed the sample to variable ratio and often denoted as *N:p*, where *N* refers to the number of participants and *p* refers to the number of variables, there are disparate recommendations regarding what an acceptable ratio is for factor analysis. Rules of thumb range anywhere from 3:1, 6:1, 10:1, 15:1, or 20:1 (Hair *et al*, 1995; Tabachnick and Fidell, 2007; Williams, Onsman, and Brown, 2010). The KMO test measures sampling adequacy for each variable in the model and for the complete model. The statistic is a measure of the proportion of variance among variables that might be common variance. The lower the proportion, the more suited the data are to Factor Analysis. The KMO index ranges from 0 to 1, with 0.50 considered suitable for factor analysis (Williams, Onsman and Brown, 2010). The KMO is given by the following formula:

Formula 2. Kaiser-Meyer-Olkin Test for Sampling Adequacy

$$\frac{\sum \sum_{i \neq j} r^2 \text{ji}}{\left(\sum \sum_{i \neq j} r^2 \text{ji} + \sum \sum_{i \neq j} a^2 \text{ji}\right)}$$

Overall Mean Sampling Adequacy (MSA) for the KMO test for each data set were above 0.90, which is indicative that the sample sizes for each data set were adequate for the fitting of a structure through exploratory factor analysis.

The next step in the analyses was determining the number of components or factors to retain from factor analysis. This was done through Parallel Analysis, Kaiser criteria, and Scree test. The Parallel Analysis works by creating a random dataset with the same numbers of observations and variables as the original data. A correlation matrix is computed from the randomly generated dataset and then eigenvalues of the correlation matrix are computed. There is disagreement in the literature about what the most appropriate cut-off value should be in consideration of factors, so these analyses used both accepted values of 0.7 and 1.0 to determine the number of factors to use in fitting the factor analysis model (Hair *et al*, 1995; Tabachnick and Fidell, 2007; Williams, Onsman, and Brown, 2010). For both criteria in the Mosher (2011) data, 2 principal factors were indicated. For both criteria in the Simpson (2015) data, 4 principal factors were indicated.

Once the number of potential factors had been identified, models were fit to the data sets, and the output of the analysis was examined to determine which variables, if any, showed cross-loading. Loadings refer to the correlation between an item/variable and a factor, those variables which show loadings on more than one factor are of concern and should be dealt with by either adjusting the cut-off point for loadings (0.3 as the standard cut-off and being a medium effect size with approximately 10% variance) to a higher loading value, or the elimination of the variable from future models. The preliminary model for both data sets showed cross loading on variables (3 cross loading variables for the Mosher (2011) data, 14 cross loading variables for the Simpson (2015) data), and those variables were removed from further modeling scenarios. Fit of a simple structure was achieved and factor analysis yielded a simple structure consisting of two factors for the Mosher (2011) data - one factor for management (organizational) and one for supervisors (group), and four factors for the Simpson (2015) data – three related to supervisors (group) and one factor for management (organizational).

Further quantitative analysis was performed for each of the two data sets regarding the collected demographic info and self-assessment regarding items such as tenure with their particular supervisor, job satisfaction, fairness of pay, etc., collected via Likert-scaled survey.

The results of the analyses of both sets of data, both through the EFA and the ANOVA, were used to generate a series of questions to be used in the collection of narratives from sample populations of both agricultural bulk goods handling/storage facilities and university research laboratories. These narratives, which are collected through a computer-based survey asking open-ended questions related to management commitment to safety, supervisor involvement in safety, job satisfaction, and fair pay. These narratives, once collected, were examined and coded according to accepted qualitative research methodology, once any common themes emerge from the data. Briefly discussed in this chapter of the dissertation, further discussion of the development, deployment, and analysis of this qualitative data can be found in Chapter 4. The qualitative data, when combined with the results of the quantitative analyses, and used in conjunction with the information gathered through a thorough literature review, serves to aid the researcher in formulating an updated definition of safety climate perceptions, using the methodology of Constructivist Grounded Theory, which is discussed in Chapter 5.

Preliminary Statistical Analysis

Part I – Data from Mosher (2011)

The 2011 study by Mosher had 187 respondents for the 32-item survey, which is a ratio of ~6:1 for respondents to questions. In order to determine the suitability of this data for use, the Kaiser-Meyer-Olkin (KMO) Sampling Adequacy Test was performed, which revealed all items of the survey had Measures of Sampling Adequacy (MSA) in excess of 0.90 with an overall MSA value of 0.96, indicating that the sample size was adequate to proceed to fitting a model through EFA. Additionally, the Bartlett's Test of Sampling Adequacy was performed to ascertain if the items in the survey were correlated adequately. Non-statistically significant values of the Bartlett's Test ($p>0.05$) indicate that the survey items are not correlated sufficiently. These tests and corresponding statistics are displayed in Table 1.

Table 1. Sampling and Factor Adequacy for Mosher (2011) data

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)

To determine the number of potential factors to run in the modeling, a combination of Parallel Analysis, Kaiser's criterion and Scree Plots were used. All three of these are methods for determining the number of components or factors to retain from factor analysis and 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 criteria data is shown in Table 2.

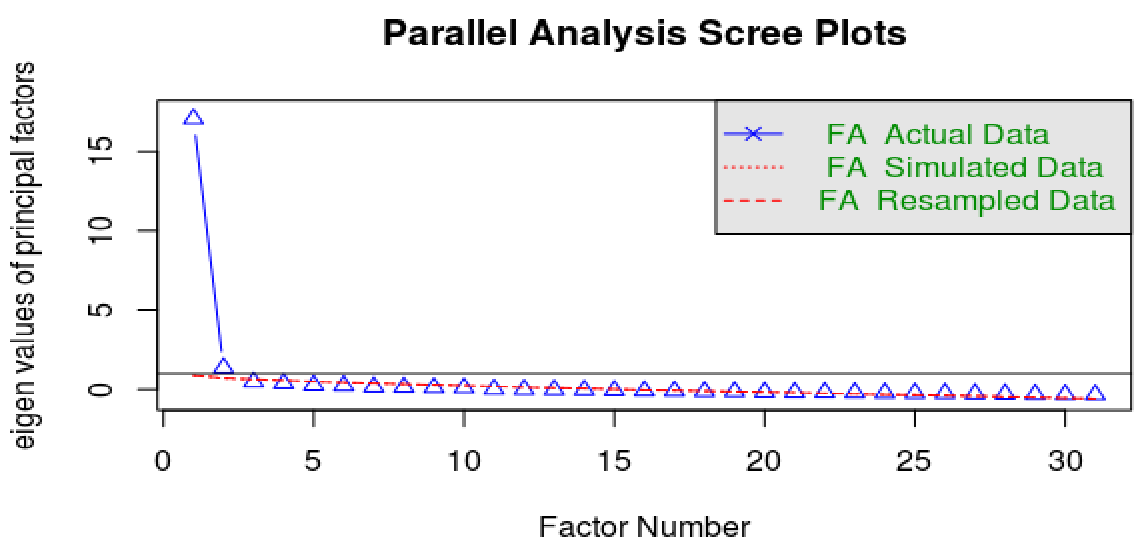

Figure 1. Parallel Analysis and Scree Plots for Mosher (2011) data

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

Identifying 2 potential factors through the use of Parallel Analysis, Kaiser criteria and Scree Plots, the initial model was run which included all the variables (items in the survey).

Initial results showed cross-loading on three variables which were eliminated. A subsequent model eliminating these three cross-loading variables was fit. This simple structure had fit indexes of 0.04 for the root mean square of the residuals (RMSR) and according to some researchers, RMSR should be less than 0.08 (Browne and Cudeck, 1993) - and ideally less than 0.05 (Stieger, 1990).; 0.061 for the root mean square error of approximation (RMSEA); and a value of 0.939 for the Tucker-Lewis Index (TLI). Values over 0.90 for the TLI are considered acceptable (e.g., Hu and Bentler, 1999). An additional fit index was calculated, the Comparative Fit Index (CFI). Specifically, the CFI compares the fit of a target model to the fit of an independent model – a model in which the variables are assumed to be uncorrelated. In this context, fit refers to the difference between the observed and predicted covariance matrices, as represented by the chi-square index. In short, the CFI represents the ratio between the discrepancy of this target model to the discrepancy of the independence model. Roughly, the CFI thus represents the extent to which the model of interest is better than is the independence model. Values that approach 1 indicate acceptable fit (Bentler, 1990). The CFI is given by the formula:

Formula 3. Comparative Fit Index

$$1 - \frac{\chi^2_{\text{finalmodel}} - \text{df}_{\text{finalmodel}}}{\chi^2_{\text{nullmodel}} - \text{df}_{\text{nullmodel}}}$$

Achieving simple structure for the model, the final step was to perform a Reliability Analysis in order to determine the extent to which the variables related to a factor are a consistent measure of that factor, and Cronbach's alpha is one way of measuring the strength of that consistency. Cronbach's alpha is computed by correlating the score for each scale item with the total score for each observation (usually individual survey respondents or test takers), and then comparing that to the variance for all individual item scores: In other words, the higher the Cronbach's alpha coefficient, the more the items have shared covariance and likely measure the same underlying concept. The Goodness of Fit, Residual Statistics, and Reliability Analysis for the Mosher (2011) data are summarized in table 3.

Table 3. Fit Statistics, Residuals, Reliability Analysis for Mosher (2011) data

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

The factors identified from the factor analysis – *Supervisor Involvement, Management Commitment,* are used as the basis of developing questions to be used in the collection of personal narratives from a purposeful sample of workers, supervisors, and managers in the industry segments identified.

Part II – Data from Simpson, 2015

The 2015 study by Simpson had 109 respondents for the 36-item survey, which is a ratio of ~3.02:1 for respondents to questions. In order to determine the suitability of this data for use, the Kaiser-Meyer-Olkin (KMO) Sampling Adequacy Test was performed, which revealed an overall MSA value of 0.83, indicating that the sample size was adequate to proceed to fitting a model through EFA. Additionally, the Bartlett's Test of Sampling Adequacy was performed to ascertain if the items in the survey were correlated adequately. The Simpson (2015) data were statistically significant for this test. The results of these tests are displayed in table 4.

Table 4. Sampling and Factor Adequacy for Simpson (2015) data

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
**KMO values between 0.8 and 1.0 indicate sampling is adequate

To determine the number of potential factors to run in the modeling, a combination of Parallel Analysis, Kaiser criteria and Scree Plots were used. Figure 2 shows this Parallel Analysis/Scree Plots while the Kaiser's criterion info is displayed in table 5.

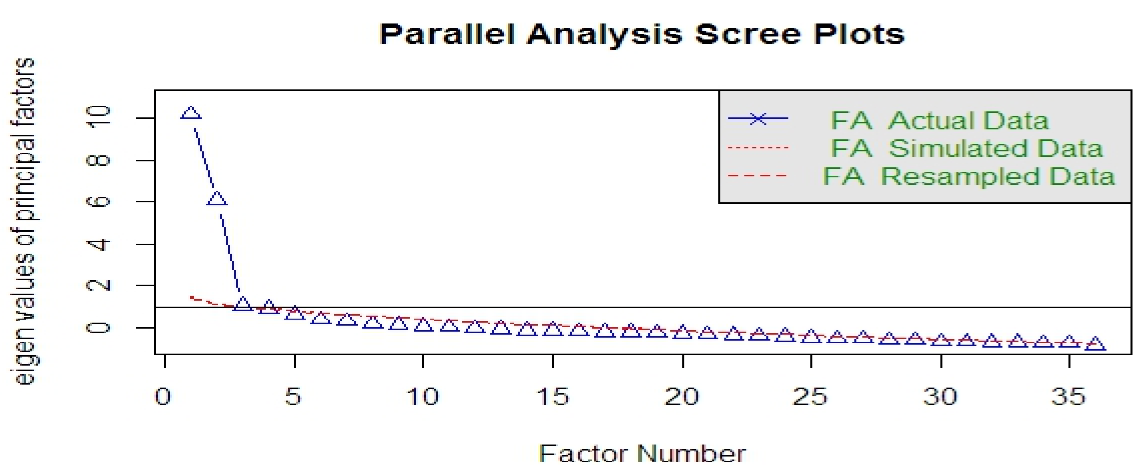

Figure 2. Parallel Analysis and Scree Plots for Simpson (2015) data

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

Identifying 4 potential factors through the use of Parallel Analysis, Kaiser's criterion and Scree Plots, the initial model was run which included all the variables (items in the survey). Initial results showed cross-loading on multiple variables, which were eliminated and a subsequent model fitted. This simple structure had fit indexes of 0.04 for the root mean square of the residuals (RMSR) and according to some researchers, RMSR should be less than 0.08 (Browne and Cudeck, 1993) - and ideally less than 0.05 (Stieger, 1990).; 0.069 for the root mean square error of approximation (RMSEA); and a value of 0.919 for the Tucker-Lewis Index (TLI). Values over 0.90 for the TLI are considered acceptable (e.g., Hu and Bentler, 1999). An additional fit index was calculated, the Comparative Fit Index (CFI), having a resultant value of 0.949. Table 6 summarizes the fit statistics and values of the reliability analysis.

Table 6. Fit Statistics, Residuals, Reliability Analysis for Simpson (2015) data

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]

Table 6. (continued)

*RMSR should be less than 0.08 (Browne and Cudeck, 1993) - and 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

It should be noted that while the Simpson (2015) data contains fit statistics values that are less than desirable, the intent of how to use the results of the quantitative analysis was to merely identify potential factors to be used in the development of questions to be used in a future qualitative data collection. The identified factors of *Supervisor Communication Reliability*, *Positive Safety Actions*, *Supervisor Dependability*, and *Supervisor Consistency* are used as the basis of developing questions to be used in the collection of personal narratives from a purposeful sample of workers, supervisors, and managers in the industry segments identified.

Qualitative Data Analysis

The factors identified through the factor analyses of the Mosher (2011) and Simpson (2015) data sets, as well as the statistically significant variables from the demographic questions in the Mosher (2011) data served as the basis for developing questions to be used in a narrative collection questionnaire distributed to and answered by a purposeful sample of participants via online medium. After an initial question asking for a participant's definition of the term "safety climate", used to frame all subsequent responses, each identified factor or variable had an associated question posed to the questionnaire participant. The questions posed to the participants were:

Question #1 to frame all responses: How would you personally define the term “safety climate”?

Factor 1 – Supervisor Involvement – Please describe in what way you feel your supervisor is involved in fostering a positive safety climate in your facility.

Factor 2 – Management Commitment – Please describe in what way you feel upper level or senior management in your facility is committed to fostering a positive safety climate.

Factor 3 – Supervisor Communication Reliability – Please describe how the reliability of a supervisor’s communication influences your perception of safety climate? i.e. a supervisor says the same thing from one time to the next or says the same things to different people or levels of the organization.

Factor 4 – Positive Safety Actions – Please describe in what way positive safety actions taken by employees or supervisors have an effect on the overall safety climate of the organization.

Factor 5 – Supervisor Dependability – Please describe in what way the dependability of a supervisor (either through things they say or things they do) influence the overall safety climate of the organization.

Factor 6 – Supervisor Personal Stability – Please describe in what way the stability of a supervisor’s personality (acts in a consistent and predictable manner, responds appropriately to situations) influence the overall safety climate of the organization.

ANOVA variable 1 – Job Satisfaction – Do you believe that your personal level of job satisfaction has an impact on the safety climate of the facility you work in?

ANOVA variable 2 – Fair Pay – Do you believe that your personal feeling regarding how fairly you are paid for your work has an impact on the safety climate of the facility you work in?

An invitation to participate in this qualitative portion of the research study was extended to a list of fifteen individuals identified as supervisors in their particular industry segment or laboratory space, with a request that this invitation be further extended by the individual to the employees working under them and the upper level management personnel above them. Twelve individuals in total completed the narrative collection portion of this research study. It is not known how many people in total were contacted by the supervisors the researcher initially contacted, however of the twelve respondents to the online survey:

Of those twelves individuals, ten were able to provide an answer to the framing question of "how would you personally define the term safety climate", and provided answers which indicated to the researcher that these respondents were able to conceptualize the term "safety climate" and could communicate that meaning in a manner which agreed or aligned with previous "definitions" of safety climate. Across the entirety of questions in the narrative collection – 12 respondents, 9 questions each = 108 questions, 93.5% of the questions were answered in such a manner as to indicate to the researcher that the respondent not only understood the question as was asked of them, but that they had some personal thoughts about how the factor/variable being investigated impacted either overall safety climate of the workplace or their own personal perception of safety climate. The 6.5% of all questions which were not answered in the aforementioned manner were either not answered at all, or were answered with an "I don't know" or "nothing", and did not provide the researcher enough information to make any meaning from them. Further and expanded discussion of this qualitative investigation can be found in chapter four.

Organization of Dissertation

This dissertation is written in the manuscript format as defined by Iowa State University's Graduate College. Chapter one is the general introduction which outlines the basic ideas behind the research and summarizes the goals and objectives. Chapter two serves as the literature review of research used as a basis for and justification of the dissertation research. Chapters three, four, and five are three manuscripts formatted for submission to specified journals. Chapter six is a general summary and interpretation of findings, recommendations for further research, and conclusions.

CHAPTER 2. LITERATURE REVIEW

This literature review addresses six broad topics. The review is not intended to be exhaustive, but topics addressed provide the theoretical grounding for topics included in the research articles and the overall dissertation research. The topics reviewed include: (1) the definition and meaning of safety climate as it exists currently as well as discussion of its historical background since inception and its role in occupational safety, (2) instruments developed and deployed in industry to assess safety climate and discussion of their strengths and shortcomings, (3) a review of previous findings on the impact employee, managerial and supervisory roles have on personal and organizational relationships with safety climate (4) discussion of concepts such as organizational trust, safety leadership, and safety perception, (5) discussion of Grounded Theory, its value to this research, and its use as a framework for, and (6) qualitative research methods and studies conducted in the vein of this research field and the need for further qualitative studies to further define safety climate perception.

Safety Climate

Safety Climate was first defined by Zohar 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*" (Zohar 1980, pg 96). 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 (Wu, Chen, and Li, 2008). 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. According to Wu, Chen, and Li, (2008), safety climate measures perceptions of the CEOs' and managers' safety commitment and action by employees, which influence the safety organization and management, safety equipment and measures, and accident investigations.

According to Zohar (2010), since the publication of the study (1980) that defined, measured and tested safety climate, little work has been done on theoretical or conceptual issues, focusing instead on issues related to direct measurement of safety climate, including factorial structures of measurement scales and their predictive ability of safety outcomes. Further, Zohar (2010), citing examples, states that "*...a number of review papers identified more than 20 empirically tested safety climate scales for manufacturing industries alone (Flin et al., 2000), covering more than 50 different variables or conceptual themes (Guldenmund, 2000). This situation resembles the study of the more generic organizational climate in which 32 different definitions were identified (Verbeke et al., 1998). Such a situation implies conceptual ambiguity and the need for greater effort directed at theoretical issues*" (pg 1517).

While the existing various definitions and measurement scales reveal some commonality which allows for identification of core concept themes and shared measurement sub-scales of safety climate (Zohar, 2010), the actual quantification of safety climate is difficult, if not impossible (Guldenmund, 2000, cited in Shannon and Norman, 2009). Further, safety climate has been identified as a "check" on whether the behavior of the people within a company, especially management and supervisors matches the rhetoric (Shannon and Norman, 2009; Mosher, Keren, Freeman, and Hurburgh, 2013). Since safety climate refers to observable behaviors, it can be and often is measured or gauged through the use of questionnaires completed by workers (Shannon and Norman, 2009).

Despite the variation in the measurement scales of safety climate, some commonality of core concepts exists which allow for identification and examination (Zohar, 2010). Additionally, recent meta-analytic studies (Nahrgang *et al*., 2008; Christian *et al*., 2009) revealed that safety climate offers the ability to predict both objective and subjective safety criteria across industries as well as countries. Through 202 published studies encompassing 236 independent samples (N=127,266), the ability of the ZSCQ or any of its derivatives has demonstrated its robustness in measuring safety climate (Zohar, 2010).

Safety Climate as Measurement Tool in OHS

An indicator is a measurable representation of an aspect of reality (Øien, Utne, and Herrera, 2011). Indicators are based on models of reality and the model predefines what the indicators can disclose (Reiman and Pietikäinen, 2012). Indicators should offer grounds for changing and modifying work practices when the results show a downward trend or when target values are not reached (Kongsvik, Almklov, and Fenstad, 2010). An indicator can be considered any measure – quantitative or qualitative – that seeks to produce information on an issue of interest and should be able to identify organizational practices and processes that lead or lag changes in the safety performance of the organization (Reiman and Pietikäinen, 2012). Leading indicators have the primary function to measure occupational health and safety (OHS) process effectiveness (Hinze *et al*., 2013), systems performance (Hohn and Duden, 2009), and organizational performance (Reiman and Pietikäinen, 2010; Reiman and Pietikäinen, 2012). Leading indicators measure those events preceding events such as injuries and fatalities, or other harm or failures at the system level (Sinelnikov, Inouye, and Kerper, 2015). Leading indicators are not necessarily the opposite of lagging indicators, but are one aspect of OHS events present and identified prior to the occurrence of an undesirable event (Harms-Ringdahl, 2009; Hale, 2009). There is a general consensus in the research for the use of leading indicators to measure OHS performance, however there is not a general consensus of the definition of what these leading indicators are (Sinelnikov, Inouye, and Kerper, 2015). To effectively assess potential effects of safety climate on injuries at work, it is essential to choose appropriate injury-related measures. Over the past decades, conventional dichotomization (i.e., high versus low injury rates or counts), objective indexes such as number of OSHA recordables, or lost-day injuries have been used (Hofmann and Stetzer, 1996; Zohar, 2000). The research on indicators started with the need to measure safety or risk. The main function of a measure of safety performance is to describe the safety level within an organization, establishment, or work unit (Øien, Utne, and Herrera, 2011).

Safety climate is one multidimensional organizational construct believed to influence the safety behavior of workers at the individual, group, or organizational level. The term safety climate is conceptualized as employees' shared perceptions regarding how safety practices, policies, and procedures are implemented and prioritized, compared to other priorities such as productivity (Smith *et al*., 2006). Safety climate predicts employees' motivation to work safely, which affects employees' safety behaviors and subsequent experiences of workplace injuries or incidents (Griffin and Neal, 2000; Mueller *et al*., 1999; Zohar and Luria, 2003).

When elevated to the level of a core value, organizations must commit considerable resources to measuring the performance of their Occupational Health and Safety (OHS) programs (Sinelnikov, Inouye, and Kerper, 2015). Despite a growing acceptance that failure-focused (lagging indicators) are less useful in helping to drive continuous improvement in an organization's OHS program (Hubbard, 2004; Agnew, Flin, and Mearns, 2013), the majority of OHS initiatives are still evaluated relying primarily on lagging metrics such as fatality and injury rates (Sinelnikov, Inouye, and Kerper, 2015). Safety indicators play a key role in providing information on organizational performance, motivating people to work on safety and increasing organizational potential for safety (Reiman and Pietikäinen, 2012). The pragmatic value of any measurement scale, according to Johnson (2007) rests with its ability to predict performance. In the case of safety climate, this means measures of climate become significant to the extent they can predict safety-related outcomes such as safe behavior, accidents, and lost workdays (Johnson, 2007).

Safety management is reliant upon systematic anticipation, monitoring and development of organizational performance (Reiman and Pietikäinen, 2012). Managers are not only interested in safety climate's effect on safe behavior, but are also interested in how safety climate influences bottom-line performance indicators like injuries, accidents, and lost work days. (Johnson, 2007). Various safety indicators play a key role in providing information on current organizational safety performance, the most common used are lagging indicators – measuring out-comes of activities or events that have already happened. A recent increased emphasis has been placed on leading indicators – which provide information for use in anticipating and developing organizational performance .(Reiman and Pietikäinen, 2012). Leading indicators identify the holes in the risk control system during routine checks, whereas the lagging indicators reveal the holes in the barriers as a result of an incident (Øien, Utne, and Herrera, 2011).

Leading indicators would therefore measure those events preceding events such as injuries and fatalities, or other harm or failures at the system level (Sinelnikov, Inouye, and Kerper, 2015). Additionally, leading indicators have the primary function to measure OHS process effectiveness (Hinze *et al*., 2013), systems performance (Hohn and Duden, 2009), and organizational performance (Reiman and Pietikäinen, 2010; Reiman and Pietikäinen, 2012). There is general consensus that the old process of looking at hardware and simple human error has changed to looking at the role of organizational performance (Reiman and Pietikäinen, 2012).

When safety climate is conceived as a leading indicator, a prospective design is utilized and safety climate data are correlated with accidents/injuries that occur in the future. When safety climate is conceived as a lagging indicator, retrospective designs are used in which safety climate data are correlated with prior accidents/injuries (Payne *et al.*, 2009). Two research designs have primarily been used to study the relationship between safety climate and safety outcomes – prospective and retrospective. In prospective designs, safety outcomes are measured for a period of time after safety climate is measured. In this design, safety climate is a leading indicator of safety outcomes. In retrospective designs, safety-related events are recorded for a period of time before safety climate is measured. In this design, safety climate is a lagging indicator of safety outcomes (Payne *et al*., 2009). In the safety climate tradition, indicators or factors have been produced, which have some prospective correlation with safety performance. Still, the observed correlations tend to be moderate or weak, and many studies show no such correlations at all (Kongsvik, Almklov, and Fenstad, 2010). Prospective designs have received less attention in the literature, and this is where future research is especially needed. Although safety climate researchers commonly posit that safety climate affects the future occurrence of accidents/injuries, relatively few studies have examined this relationship prospectively (Payne *et al*., 2009). In relation to finding proactive indicators, some studies have established a climate/ safety performance relationship, which would imply that climate measures could be useful for preventing accidents. In other words, such measures can communicate that something is wrong, although from an anthropological perspective, they provide limited grounds for analysis (Kongsvik, Almklov, and Fenstad, 2010). A product of researcher attention into this field has been the creation of several quantitative questionnaires. Researchers documented psychometric properties (reliability, construct validity, content validity) for these instruments, but significant deficiencies remained with respect to the establishment of an association between safety climate and safety-related outcomes (Cooper and Phillips, 2004).

The initial research on developing indicators or metrics for major hazards started with a focus on direct or 'lagging' indicators, i.e., after-the-event type of indicators (Øien, Utne, and Herrera, 2011). This approach counts the number of accidents or incidents or near misses, however, these indicators are not very useful as pre-warnings or early warnings – for which one needs to look further back in the causal chain, at the underlying causes and the condition of the factors that leads to accidents (Øien, Utne, and Herrera, 2011). When safety climate is a lagging indicator of safety outcomes, prior measures of safety outcomes are related to more recent measures of safety climate. In other words, safety outcomes are conceptualized as the antecedent or cause and safety climate is conceptualized as the consequence or the effect (Payne *et al*., 2009). Lagging indicators are related to reactive monitoring and show when a desired safety outcome has failed, or when it has not been achieved. Examples of lagging indicators are the number of unexpected loss-of-containment incidents and failures of safety critical instrumentation/alarms (Øien, Utne, and Herrera, 2011).

Traditional safety climate research is dominated by a psychometric tradition which implies a quantitative methodology and the need for exploratory and confirmatory factor analyses to reveal underlying structure of the concept (Kongsvik, Almklov, and Fenstad, 2010). In considering safety climate as a cultural analysis, Haukelid (2008) states, *"In cultural analyses, the general aim is usually to achieve a deeper understanding of a social phenomenon that is difficult to explain from single cause– effect relationship, or to be measured or tested under exact conditions"* (pg 424). This statement would seem to illustrate that safety climate cannot be easily measured in a factorization of a social, anthropological phenomena (Kongsvik, Almklov, and Fenstad, 2010). The current view regarding safety has developed toward a more systems-focused conception where safety is now more than the negation of risk (Reiman and Pietikäinen, 2012). Organizational accidents have complex origins and capturing this complexity through leading/lagging indicators – which are, by nature, simplifications of data and do not account for the complex and intertwined influences on occupational risk – is a challenge (Kongsvik, Almklov, and Fenstad, 2010). Currently, few research studies have been conducted to attempt to establish a link between an organization's operations and its processes, and the common tool used to assess – questionnaires – have been criticized on methodological grounds (Strauch, 2015). Guldenmund (2000) warns that safety climate analyses themselves are not sufficient to instigate fruitful occupational safety interventions, and states that more detailed studies of each organization's ‘‘basic assumptions" might be necessary for such action. Although the validity and reliability of the ZSCQ has been well established, Zohar (2010) states "...the time has come to re-focus our attention on theoretical and conceptual issues...” (pg 1517), where the identification, research, and examination of these conceptual issues could reduce ambiguity and lead to the emergence of a better developed safety climate theory (Zohar, 2010).

In a research study conducted by Sinelnikov, Inouye, and Kerper (2015), participants put forth that current taxonomies of leading and lagging indicators should not be too granular or static. It was further stated that an in-place taxonomy should allow for data analysts being afforded the ability to organize the data, the OHS professional being afforded the ability to communicate the information up and down the organizational hierarchy, and management and senior executives should be able to understand the information and be afforded the ability to act upon it (Sinelnikov, Inouye, and Kerper, 2015).

Safety performance indicators are needed in order to be able to monitor the current level of safety, to follow the effects of proactive safety work as well as to anticipate emerging vulnerabilities within the system as well as in its environment (Reiman and Pietikäinen, 2012). Researchers should, according to Payne *et al*., (2009), make an effort to examine both retrospective and prospective accident/injury data when studying safety climate. Further, Payne *et al*., (2009) state that both the prospective and retrospective relationship of safety climate to safety performance are important, and that safety climate can be regarded as both a leading and lagging indicator of safety-related events (Payne *et al.,* 2009). Another approach to establishing organizational safety indicators is the risk analyses tradition, which is grounded in engineering science. Risk analyses have mainly focused on technical issues, but much effort has also been invested in including organizational and managerial factors in risk assessments (Kongsvik, Almklov, and Fenstad, 2010).

Safety Climate and Organizational Relationships

Numerous research studies have investigated to what degree organizational relationship factors aid in explaining overall safety climate strength; these studies have investigated factors such as organizational tenure (Beus *et al*., 2010), safety leadership (Conchie, Moon, and Duncan, 2013; Du and Sun, 2012; Eid *et al*., 2012; Kapp, 2012; Künzle, Kolbe, and Grote, 2010; Liou, Yen, and Tzeng, 2008; Lu and Yang, 2010), work autonomy (Clarke, 2006; Piccolo and Colquitt, 2010), worker self-efficacy (Parker, Wall, and Cordery, 2001; Walumbwa, Cropanzano, and Goldman, 2011), organizational social support (Conchie, Moon, and Duncan, 2013; Huang, You, and Tsai, 2012), safety action reciprocity (DeJoy *et al*., 2010), safety management (DeJoy, 2010; Hale *et al*., 1997; Hale *et al*., 2010; Hsu, Li, and Chen, 2010; Hurst *et al*., 1996; Hurst, 1997; Luria and Morag, 2012; Mosher *et al*., 2013), affective evaluations (DeJoy, 2005; Guldenmund, 2007), organizational trust (Kath, Magley, and Marmet., 2010; Luria, 2010), and risk management (Fernández-Muñiz, Montes-Peón, and Vázquez-Ordás, 2007, 2009, 2014). Safety climate is a measure that is constructed and reconstructed on a continual basis, not only through direct interactions with the technical environment, but also through perceptions of concern and affective evaluations throughout the organization (DeJoy, 2005; Guldenmund, 2007). Safety management should be about managing the socio-technical system, not about managing and optimizing certain indicators (Reiman and Pietikäinen, 2012).

Organizational Tenure

In a 2010 study (Beus *et al*., 2010), the relationship between the organizational tenure of employees at a given worksite and safety climate strength (i.e., the variability of employees' perceptions of the policies, procedures, and practices regarding workplace safety) was examined. The results of this study revealed a positive correlation between average worksite tenure and safety climate strength – higher average tenure was associated with stronger safety climates. Furthermore, the study results revealed that the positive correlation was curve-linear, meaning that at higher levels of worksite tenure, smaller increases in the group's average tenure improved climate strength to a greater extent than at lower levels of worksite tenure (Beus *et al*., 2010). Beus (2010) postulated that the relationship between organizational tenure and the development of climate strength had important managerial implications (Beus *et al*., 2010).

Safety Leadership

A growing body of research supports the importance of supervisors' safety leadership in promoting employees' engagement in safety (Conchie, Moon, and Duncan, 2013). Despite the research interest in safety leadership, less attention has been given to the factors that influence supervisors' engagement in safety leadership (Conchie, Moon, and Duncan, 2013). Briefly defined, 'engagement' is the extent to which supervisors show energy, enthusiasm, feel a sense of inspiration, and are fully concentrated (Schaufeli and Bakker, 2004).

Data gathered in focus groups in the UK construction industry from sixty-nine supervisors showed that production demands, role overload, workforce characteristics, and formal procedures hindered supervisors' engagement in safety leadership. These factors are contrasted against social support from the organization and co-workers and perceived autonomy, both of which promoted supervisors' engagement in safety leadership. (Conchie, Moon, and Duncan, 2013). It is unclear however when speaking of occupational safety in a larger context, specifically which demands supervisors perceive as challenges which increase their engagement in safety leadership, and which demands those supervisors consider to be a hindrance (Conchie, Moon, and Duncan, 2013).

Colangelo and Bowers (2012) identified and discussed 5 primary factors of effective safety leadership which are 1) Field Presence – showing the project team and workforce that you care, but you are setting the standard for the entire project team, and establishing the importance of demonstrating safety leadership; 2) Effective Communication - the ability to effectively communicate to the project team, your sub-contractors, and the workforce is paramount to achieving safety excellence; 3) Feedback Mechanism – developing a direct avenue of communication between the workforce and management; 4) Accountability – it is paramount that all discipline is fair, just and consistent across all job classifications, everyone must be held accountable for their actions… starting with Management; and 5) Benchmarking – Establishing a continuous improvement road map will help ensure your safety programs and systems are keeping pace with your project management systems (Colangelo and Bowers, 2012).

Problematic for safety leadership is workload demands. Through depleting supervisors' energy, availability, and time, they consequently deplete safety-related interactions with employees (Conchie, Moon, and Duncan, 2013). By providing supervisors with support, these demands are reduced, as are others such as coordinating multiple contractor groups, time schedules and access to resources – which has the effect of enhancing feelings of self-efficacy to engage in leadership behaviors that expand beyond formal requirements (Conchie, Moon, and Duncan, 2013).

A 2008 study conducted by (Wu, Chen, and Li), which was conducted among 465 participants and analyzed using path analysis, found that safety climate partially mediated the relationship between safety leadership and safety performance. Additionally, existing correlation analysis showed that safety controlling, one factor of safety leadership, had main influence on CEOs and managers' safety commitment and action in safety climate, and on safety organization and management, safety equipment and measures, and accident investigations in safety performance (Wu, Chen, and Li, 2008). Previous studies have found that aspects of safety climate, such as management attitudes and communication, have an effect on organizational safety-related behaviors (Kath, Magley, and Marmet, 2010).

A meta-analysis by Clarke (2006) showed that high levels of safety climate led to increased safety participation and compliance. However, other researchers (Michael *et al*., 2006) argue that these aspects of safety are not sufficient in explaining organizational outcomes, and call for further research to find mediators or moderators to better explain this relationship. Cooper and Phillips (2004) found support for their hypothesis that differences in employee perceptions will vary among the different departments of a manufacturing industry (Kath, Magley, and Marmet, 2010). Specifically, the importance of safety varies across jobs that people perform. For example, it seems reasonable that safety would have increased importance for someone working in a steel mill than for someone working in a clerical role in an office setting. Previous research has hinted at this relationship, but has not examined it in detail. For instance, a recent study was conducted that found employees' perceptions of safety climate varied due to job title (Wu, Liu, and Lu, 2007).

Postulating the need for further avenues of research which allow for the examination of more theoretical constructs of safety climate, Zohar (2010), puts forth three major points:

1. Postulating that the targets of perceptions of safety climate relate to system-level attributes such as prioritizing competing demands, espousal-enactment gaps or discrepancies, internal consistencies among policies and procedures (pg 1521).
2. Postulating that the targets of perceptions of safety climate relate to organization or group-levels of analysis – such as senior management commitments and policies vs. supervisory or co-worker practices (pg 1521).
3. Examination of the level-specific perceptions of safety climate of employees (non-managerial nor supervisory), and development of level-specific scales of the safety climate questionnaire to reduce ambiguity (pg 1521).

Work Autonomy

Previous research has shown that ethical leaders encourage their subordinates to work autonomously on their job tasks (Piccolo *et al*., 2010) and through their actions increase employees' sense of self-efficacy (Walumbwa *et al*., 2011). Higher levels of job autonomy (Clarke, 2008) and self-efficacy (Parker, Wall, and Cordery, 2001) in turn, have been shown to promote safety behavior in the workplace (Chughtai, Byrne, and Flood, 2015). Employees, often aware and attuned to the underlying values of the organization, will adopt them as internalized normative beliefs to guide their behavior and achieve the organization's desired end-states (Rokeach, 1979). The values of the organization that emphasize the importance of human resources to the success of the organization should lead to supportive policies and practices related to workplace safety and health (DeJoy *et al*., 2010). Other safety research has demonstrated positive relationships between various supportive management practices and safety-related perceptions and behaviors (DeJoy *et al*., 2010).

Organizational Social Support

Evidence suggests that safety climate perceptions involve a process of social exchange (DeJoy *et al*., 2010). Various theories (Hofmann and Morgeson, 1999; Mearns and Reader, 2008) have been used to explain the social exchange relationship between organizations and employees, but theories involving perceived organizational support have been most common (DeJoy *et al*., 2010). Perceived organizational support has long been recognized as an important factor in research on organizational commitment, but only more recently has it gained visibility in the safety climate literature (DeJoy *et al*., 2010). Demonstration of management's commitment to safety and health through policies and actions that show employees that they are valued and supported by the organization leads to employees that perform better not just in the realm of safety, but also in terms of overall work performance and organizational citizenship (e.g., Mathieu and Zajac, 1990; Meyer *et al*., 2002).

Perceived organizational support signals the employer's commitment to their employees and influences employee attitudes and behaviors (Cole *et al*., 2002; Eisenberger *et al*., 2001). Employee support is then reciprocated when their efforts are calibrated to achieve organizational goals, including those related to safety (DeJoy *et al*., 2010). Further research (Coyle-Shapiro and Kessler, 2000) indicates that employee perceptions of management meeting its obligations leads to both increased employee commitment, as well as trust in the organization (Robinson, 1996). Alternatively, from the worker's perspective the provision of safe working conditions is an obligation of the employer, and the perception that this obligation is not being met is viewed as a breach of contract (DeJoy *et al*., 2010). The reviewed literature (e.g., Mathieu and Zajac, 1990; Meyers *et al*., 2002) suggests that organizational commitment is negatively correlated to employee withdrawal behavior, including absenteeism, withdrawal cognitions, turnover, and turnover intentions, and positively correlated to job performance and organizational citizenship behavior (DeJoy *et al*., 2010). Actions taken to enhance safety climate in a facility can result in more committed and loyal employees. Such citizenship, where the employees go above and beyond established job responsibilities, are perhaps of importance in achieving and maintaining high levels of organizational safety performance in complex and/or demanding safety environments. (DeJoy *et al*., 2010). It should be stated that a facility having committed employees is good for workplace safety, but employee commitment is better considered a starting point rather than an ending point in the quest to minimize injury and other losses (DeJoy *et al.*, 2010).

A 2010 study by DeJoy *et al*. Found that an organization's occupational safety and health policies and programs (OSHPandP) impacted both safety climate and organizational commitment, and as was hypothesized in the study, perceived organizational support (POS) partially mediated both of these effects. Additionally, safety climate was related to perceived safety at work and self- reported work accidents, while organizational commitment was related to withdrawal behaviors (turnover intention; absenteeism, and tardiness) and employee vitality. (DeJoy *et al*., 2010).

Safety Action Reciprocity

The general trend in the research literature that investigates exchange relationships within work organizations focuses on the concept of reciprocity – this means that an individual who provides a service for another does so with the expectation that there will be some future positive return for them based on this action (DeJoy *et al*., 2010). When this reasoning is extended to workplace safety, when managers and supervisors demonstrate their commitment to and support of safety, employees should reciprocate by expending greater efforts to follow safe work practices and other safety-related recommendations (DeJoy *et al.*, 2010). Eisenberger *et al. (*1986) argue that employees' beliefs about an organization's concern for and commitment to them are associated with reciprocal employee commitment or attachment to the organization. Stated alternatively, the employees in a facility will self-evaluate their treatment by the organization and respond accordingly (DeJoy *et al.*, 2010).

Rhoades and Eisenberger (2002), when conducting a meta-analysis of seventy research studies, concluded that employees' general beliefs that their organization values their contributions and is concerned about their well-being are associated with increased job performance, less withdrawal from active participation in workplace safety, and high levels of affective commitment to the organization (DeJoy *et al.*, 2013). The Rhoades and Eisenberger meta-analysis (2002) identified three antecedents of perceived occupational support: fairness, supervisor support, and organizational rewards and working conditions. Each antecedent is representative of some type of favorable treatment or valuation from the organization (Rhoades and Eisenberger, 2002). Logically, these positive or favorable treatments should enhance perceived occupational support among employees (DeJoy *et al*., 2010). Despite workplace safety typically being a mandated responsibility for managerial staff, management does have a considerable amount of latitude in determining how their responsibility is structured and executed (DeJoy *et al*., 2010). Further, evidence from perceived occupational support literature (e.g., Armeli *et al*., 1998) is suggestive that the perceived occupational support of an organization is strengthened when that organization's employees believe that the positive experiences they experience at work are a direct result of voluntary, purposeful actions undertaken by management (DeJoy *et al*., 2010).

Safety climate perceptions are in part a reflection of employee feelings and emotions about the support they receive from their organization and how management fulfills its social obligations related to workplace safety (Guldenmund, 2007). It is an oversimplification to state that safety climate is merely feelings and emotions (DeJoy *et al*., 2010). As stated in Rochlin (1996), organizations with high-performance safety programs, especially those in high-hazard industries, demonstrate a positive engagement with occupational safety that exceeds the basic, conventional safety technologies and methods of control, and instead demonstrates a proactive process of anticipating and planning for untoward events and circumstances (DeJoy *et al.*, 2010).

Shared Perceptions of Safety Climate

In the study conducted by Bryden (2002), he identified a number of critical behaviors for safety, namely: engaging everyone with relevant experience in strategic safety decision-making behaviors; articulating an attainable vision of future safety performance; demonstrating personal commitment to safety symbolically; and being clear and transparent when dealing with safety issues. O'Dea and Flinn (2001) examined the relationship between the perceptions of safety behaviors and the actual behaviors exhibited by employees in their study and whether the tendency for employees to respond in a positive correlation to their expressed perceptions.

These aspects of perceptions of safety climate, safety tendency behavior related to safety perceptions, and strategic safety decision making are ones which will be addressed through the course of this proposed research. Furthermore, most researchers used measurement instruments which attempted to assess the nature of empowerment and individual employee's cognitive feelings in relation to his/her contributions to the organization (Boudrias *et al*., 2009). Such conditions were comprised of employees' traits, abilities, personal company/cultural involvement, and other dominant cultural values, (Spreitzer, 1996; Forrester, 2000; Yukl and Becker, 2006).

Safety Climate Measurements and Relationships

Management attitudes toward safety include employees' perception that their supervisors view safety as important; upward safety communication refers to the comfort that subordinates feel in bringing safety-related information to their supervisors. Because safety climate has been conceptualized as shared perceptions, it naturally indicates a need to be aggregated to a group level (Zohar, 2000; Zohar and Luria, 2005). When managers alert subordinates to the importance of safety, they are outwardly communicating their perceptions about the issue. In doing so, they are expressing their concern for the well-being of the employees. (Kath, Magley, and Marmet 2010). For example, Whitener *et al*., (1998) theorize that managers who are accurate in their communication, provide adequate explanations, and keep the lines of communication open encourage trust among their employees.

Safety Climate and Qualitative Research Methods

Safety climate research has been dominated by a psychometric tradition implying a quantitative methodology and the need to use factor analyses to reveal the underlying structure of the concept (Kongsvik, Almklov, and Fenstad, 2010). Haukelid (2008) claims

"In cultural analyses, the general aim is usually to achieve a deeper understanding of a social phenomenon that is difficult to explain from single cause– effect relationship, or to be measured or tested under exact conditions" (pg 424). This discrepancy between the phenomenology of safety climate and its currently utilized research methodology is paradoxical (Kongsvik, Almklov, and Fenstad, 2010). Guldenmund (2000) states safety climate analyses are insufficient to instigate fruitful interventions and claims that more detailed studies of organizational ''basic assumptions" are necessary.

Organizational safety needs a continuous focus on both leading and lagging indicators; a focus on both lagging indicators of past deficiencies and leading indicators of current technical, organizational, and human conditions (Reiman and Pietikäinen, 2012). In relation to discovering proactive or leading indicators, it should be noted that some studies have established a relationship between safety climate and safety performance – implying that safety climate measures could be useful in preventing accidents.

Qualitative Research and Grounded Theory

A basic issue exists where it is questioned to what degree organizational safety can be reduced to a set of quantitative factors as is used in existing safety climate and risk analysis traditions, and whether organizational safety should be approached in a more holistic manner (Kongsvik, Almklov, and Fenstad 2010). When the objects of safety are concrete, physical objects, it makes good sense to treat them as variable quantities that can be measured and broken down into components or factors. However, when this view is transferred to organizational safety, where social processes and interactions are fundamental to their function, it is useful to regard these different aspects (e.g. management, competence, communication) more holistically, and thereby are better suited to be examined using qualitative approaches (Kongsvik, Almklov, and Fenstad, 2010). Qualitative research includes a variety of methodological approaches with different disciplinary origins and tools (Lingard, Albert, and Levinson, 2008).

Increasingly, qualitative researchers are combining methods, processes, and principles from two or more methodologies over the course of a research study (Lal, Suto, and Ungar, 2012). Researchers who combine methods might do so at some or all stages of the research process, including data collection, data analysis, and representation of findings (Lal, Suto, and Unger, 2012). An argument against the use of qualitative methods is that they are time consuming and resource intensive, which when thought of in a cost/benefit construct, may not always be suitable for all organizational safety challenges. However, many of the existing safety indicator approaches may not provide sufficient and necessary information (Kongsvik, Almklov, and Fenstad, 2010). Qualitative methods have potential to provide reflection and organizational learning, thereby expanding understanding and allowing for the identification of new hazards and new ways of expressing them (Kongsvik, Almklov, and Fenstad, 2010). Mixed methods research, which combines elements from both qualitative and quantitative paradigms to produce converging findings in the context of complex research questions must be explicit and justified in terms of the sequence of methods (concurrent, qualitative first, or quantitative first). The priority among methods (equal, or either method prioritized), and the nature and timing of integration (full or partial, during data collection, analysis, or interpretation) must also be considered (Lingard, Albert, and Levinson, 2008). Because qualitative and quantitative methods derive from different traditions, mixed methods research must take care to negotiate back and forth between these different approaches rather than dichotomizing their values and methods. Qualitative research emphasizes an inductive-subjective-contextual approach and quantitative research emphasizes a deductive-objective-generalizing approach, but these broad tendencies are neither absolute nor mutually exclusive (Lingard, Albert, and Levinson, 2008). Among the most recognized qualitative methodologies are: phenomenology, ethnography, grounded theory, and narrative inquiry. Examples of methods developed within these traditions include: bracketing, participant observation, constant comparative analysis, and narrative interviewing, respectively (Lal, Suto, and Unger, 2012). Grounded Theory, which was developed in 1967 by Glaser and Strauss, is used to generate theories regarding social phenomena and to develop higher level understanding grounded in, or derived from, systematic analyses of data. Grounded theory is an appropriate research tool when the study of social interactions aims to explain a process, not to test or verify an existing theory (Lingard, Albert, and Levinson, 2008). Grounded Theory is an inductive research methodology consisting of three prevailing traditions: Classic, Straussian, and Constructivist Grounded Theory (Kenny and Fourie, 2015). To better understand psychological and social processes in relation to safety at work it is therefore important to investigate how safety climate relates to more generic psychosocial conditions in the organization (Tholén, Pousette, and Törner, 2013). Key features of grounded theory are its iterative study design, theoretical (purposive) sampling, and system of analysis. An iterative study design entails cycles of simultaneous data collection and analysis, where analysis informs the next cycle of data collection (Lingard, Albert, and Levinson, 2008). A social constructionist approach to grounded theory allows researchers to address ‘why’ questions while preserving the complexity of social life. Grounded theory not only is a method for understanding research participants' social constructions but also is a method that researchers construct throughout inquiry (Lingard, Albert, and Levinson, 2008). How, when, and to what extent grounded theorists invoke social constructionist premises depends on their epistemological stance and approach to research practice (Kenny and Fourie, 2015).

CHAPTER 3. USE OF EXPLORATORY FACTOR ANALYSIS TO IDENTIFY FACTORS INFLUENCING SAFETY CLIMATE IN TWO WORK ENVIRONMENTS

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Abstract

Numerous studies have utilized the Zohar Safety Climate Questionnaire and instruments derived from it to quantify safety climate in an industrial workplace and demonstrate a correlation between safety climate and safety performance. Two industrial sectors that have historically been under-represented in previous studies were agricultural bulk goods handling/storage and university research laboratories. This study utilized existing data sets from these two occupational sectors for analysis through Exploratory Factor Analysis and Analysis of Variance, in order to determine which latent factors, if any, influenced safety climate perceptions of the populations. Results from these two data sets indicate that six latent factors are present to explain safety climate: *Supervisor Involvement, Management Commitment, Supervisor Communication Reliability, Positive Safety Actions, Supervisor Dependability,* and *Supervisor Consistency.* While factors were identified, little is yet known regarding the magnitude of their influence on perceptions of safety climate in the workplace.

KEYWORDS: Safety Climate, Agricultural Safety, Laboratory Safety, Safety Analysis

Introduction

Safety climate measurement has been explored by researchers for more than 50 years. The first discussion of climate as it relates to the safety field was reported by Keenan, Kerr, and Sherman (1951), who correlated the physical work environment and the overall psychological climate of the employees. 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 and Griffin, 2000; Guldenmund, 2000; Zohar, 1980, 2000, 2002a, 2002b, 2003). Safety climate is a multidimensional construct believed to influence the safety behavior of workers at the individual, group, or organizational level (Smith *et al.*, 2006), yet is only one factor contributing to safe behavior and influencing accident and injury rates. (Beus *et al.*, 2010).

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
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.

While often measured as an individual perception, there is evidence to suggest that climate is widely shared in organizations. Ostroff, Kinicki, and Tamkins (2003) proposed that organizational climate is a shared perception of organizational policies and norms. People strive to "attach meaning to or make sense of clusters of psychologically related events" (Schneider and Reichers, 1983; p. 21). Climate measures provide information regarding the behaviors that are rewarded, supported, and expected in the workplace (O'Reilly and Chatman, 1996; Schneider and Reichers, 1983). Workers are commonly exposed to the same organizational stimuli such as policies, processes, and procedures. In the workplace, people experience numerous events that can pertain to a variety of groupings, and thus there are "climates for" various aspects of organizational life (Schneider and Reichers, 1983; Schneider, Salvaggio, and Subirats, 2002). Similarly, organizations recruit and retain similar people who respond to the organization's environment (Adamshick, 2007).

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 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; Griffin and Neal, 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, however, 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 (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). Summarized, these studies 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.

While a higher level of safety climate is likely to lead to positive safety behaviors and a lower level of safety climates is likely to lead to negative safety behaviors, variability in employees' behavior is likely within a given safety climate. Not all employees in a positive (or negative) safety climate will exhibit positive (or negative) safety behaviors. One source of this variability is in individual perceptions of safety climate, and how this variability in individual perception affects the "sharedness" of a climate (Dickson, Resick, and Hanges, 2006; Schneider, Salvaggio, and Subirats, 2002). Schneider, Salvaggio, and Subirats (2002) postulated that strong safety climate, regardless of climate level, is expected to be more predictive of group behavior than a weak climate. The behavior of a group with more similar individual perceptions (greater safety climate consensus) should be predicted with more ease than the behavior of a group with less similar individual perceptions (lesser safety climate consensus) and found that greater consensus was related to behavioral similarity among group members (Beus *et al*., 2010).

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. These hazards exist also in both agricultural occupational sectors as well as university and college laboratories, and the risks in these laboratories are not necessarily lower than those in general industries.

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).

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.

Materials and Methods

This research seeks to better understand the factors 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:

A. Are previously identified constructs evident in an agricultural facility?

B. Are previously identified constructs evident in university laboratories?

C. What differences, if any, exist between the agricultural bulk commodity handling facility and University research laboratories?

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". Data from university research laboratories consisted of 109 responses on a 36-item survey. 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.

Bartlett's Test for Correlation Adequacy (aka Bartlett's Test of Sphericity) is a way to test the assumption that there are at least some correlations among the variables so that coherent factors can be identified. It is desirable to have some degree of collinearity among the variables but not an extreme degree or singularity among the variables (Schreiber, Nora, and Stage, 2006). The test statistic from this test should be statistically significant at the $p<0.05$ value to be deemed acceptable (Williams, Onsman, and Brown, 2010).

Kaiser-Meyer-Olkin (KMO) is a measure of how well suited a data set is for Factor Analysis. The test measures sampling adequacy for each variable in the model and for the complete model. The statistic is a measure of the proportion of variance among variables that might be common variance. The lower the proportion, the more suited the data is to Factor Analysis. The KMO index ranges from 0 to 1, with 0.50 considered suitable for factor analysis (Williams, Onsman and Brown, 2010). There is disagreement in the literature regarding what constitutes an acceptable sample size for factor analysis as well as an acceptable ratio of participant-to-variables. Often termed the sample to variable ratio and often denoted as N:p, where N refers to the number of participants and p refers to the number of variables, there are disparate recommendations regarding what an acceptable ratio is for factor analysis. Rules of thumb range anywhere from 3:1, 6:1, 10:1, 15:1, or 20:1 (Hair *et al*, 1995; Tabachnick and Fidell, 2007; Williams, Onsman, and Brown, 2010).

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.

Comparative Fit Index (CFI) compares the fit of a target model to the fit of an independent model – a model in which the variables are assumed to be uncorrelated. In this context, fit refers to the difference between the observed and predicted covariance matrices, as represented by the chi-square index. Values that approach 1 indicate acceptable fit (Hu and Bentler, 1999). The CFI is represented by the formula:

Equation 1: Comparative Fit Index

$$1 - \frac{\chi^2_{\text{finalmodel}} - \text{df}_{\text{finalmodel}}}{\chi^2_{\text{nullmodel}} - \text{df}_{\text{nullmodel}}}$$

The Tucker-Lewis Index (TLI), also known as the Non-Normed Fit Index (NNFI), is a goodness-of-fit index that analyzes the discrepancy between the chi-squared value of the hypothesized model and the chi-squared value of the null model. Values for the NNFI should range between 0 and 1, with a cutoff of 0.95 or greater indicating a good model fit (Hu and Bentler, 1999).

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 these are methods for determining the number of components or factors to retain from factor analysis and 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 Scree Plots

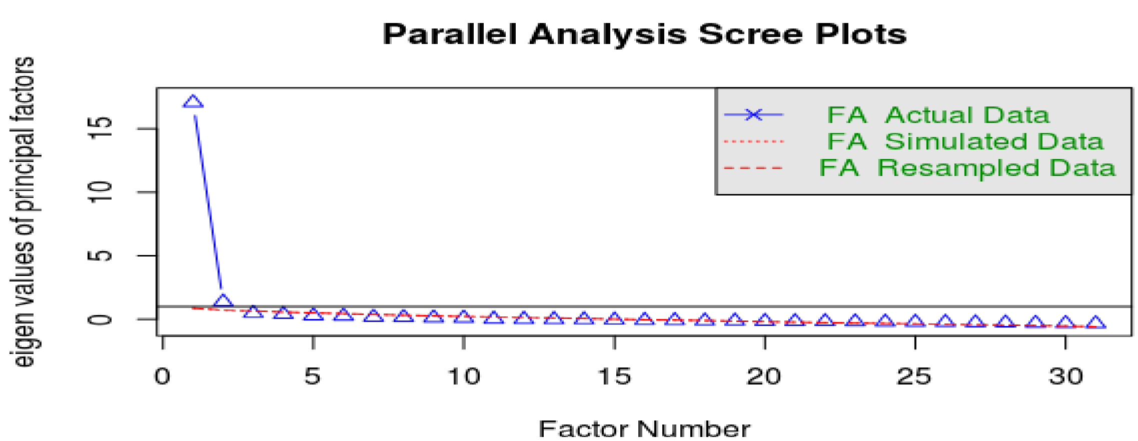

Table 2. Numbers of Indicated Factors via Kaiser's Criterion Values

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.

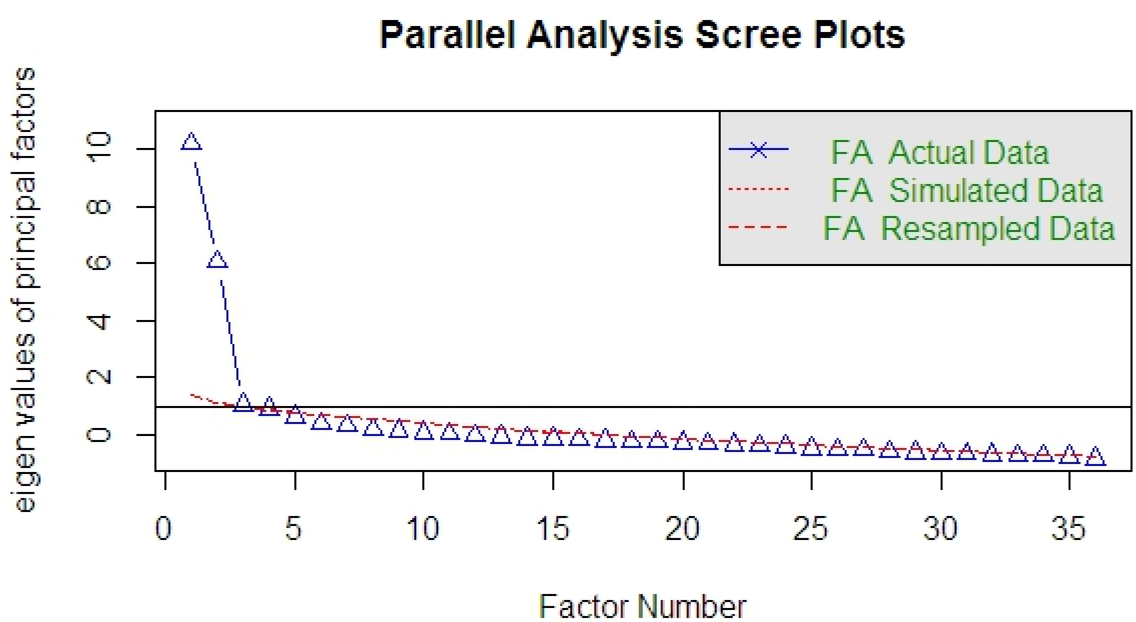

Figure 2. Parallel Analysis Scree Plots

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

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)	0.9491	
Cronbach's alpha (factor 1 – *Sup. Comm. Reliability*)	0.892	95% C.I. [0.86, 0.92]
Cronbach's alpha (factor 2 – *Positive Safety Actions*)	0.903	95% C.I. [0.87, 0.93]
Cronbach's alpha (factor 3 – *Supervisor Dependability*)	0.614	95% C.I. [0.47, 0.76]
Cronbach's alpha (factor 4 – *Supervisor Consistency*)	0.775	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 – a*gricultural 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 – a*gricultural 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 – u*niversity 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 – u*niversity 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 – u*niversity 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 – u*niversity 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 A – *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 B – *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 C – *What differences, 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). Haukelid (2008) claims that, ''*In cultural analyses, the general aim is usually to achieve a deeper understanding of a social phenomenon that is difficult to explain from single cause– effect relationship, or to be measured or tested under exact conditions*" (pg 424). The words imply that safety climate is a cultural phenomenon, and also that the factorization of safety culture/climate is opposed to the holistic approach of anthropology (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).

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: 1) does this new information, if it is revealed, agree with or reinforce the information from the quantitative analysis, or 2) does this new information, if it is revealed, disagree with or refute the information from the quantitative analysis? The researcher postulates that by utilizing established quantitative methodology to identify factors which could be used in future research studies carried out under different ontology/epistemology and methodology, an opportunity exists to investigate safety climate and its influences to a deeper level. In doing so, the usage of the safety climate measure can be extended to further benefit the safety and health of safety-sensitive workplaces.

References

Adamshick, M. H. (2007). *Leadership and safety climate in high-risk military organizations* (Doctoral dissertation, University of Maryland, College Park).

Agnew, C., Flin, R., and Mearns, K. (2013). Patient safety climate and worker safety behaviours in acute hospitals in Scotland. *Journal of safety research*, *45*, 95-101.

Ajslev, J., Dastjerdi, E. L., Dyreborg, J., Kines, P., Jeschke, K. C., Sundstrup, E.,... and Andersen, L. L. (2017). Safety climate and accidents at work: Cross-sectional study among 15,000 workers of the general working population. *Safety science*, *91*, 320-325.

Barbaranelli, C., Petitta, L., and Probst, T. M. (2015). Does safety climate predict safety performance in Italy and the USA? Cross-cultural validation of a theoretical model of safety climate. *Accident analysis and prevention*, *77*, 35-44.

Beus, J. M., Bergman, M. E., and Payne, S. C. (2010). The influence of organizational tenure on safety climate strength: A first look. *Accident analysis and prevention*, *42*(5), 1431-1437.

Beus, J. M., Payne, S. C., Bergman, M. E., and Arthur Jr, W. (2010). Safety climate and injuries: an examination of theoretical and empirical relationships.

Cheyne, A., Cox, S., Oliver, A., and Tomás, J. M. (1998). Modeling safety climate in the prediction of levels of safety activity. *Work and stress*, *12*(3), 255-271.

Christian, M. S., Bradley, J. C., Wallace, J. C., and Burke, M. J. (2009). Workplace safety: a meta-analysis of the roles of person and situation factors.

Clarke, S. (2006). The relationship between safety climate and safety performance: a meta-analytic review.

Cooper, M. D., and Phillips, R. A. (2004). Exploratory analysis of the safety climate and safety behavior relationship. *Journal of safety research*, *35*(5), 497-512.

Cox, S. J., and Cheyne, A. J. T. (2000). Assessing safety culture in offshore environments. *Safety science*, *34*(1), 111-129.

Dedobbeleer, N., and Béland, F. (1991). A safety climate measure for construction sites. *Journal of safety research*, *22*(2), 97-103.

DeJoy, D. M., Schaffer, B. S., Wilson, M. G., Vandenberg, R. J., and Butts, M. M. (2004). Creating safer workplaces: assessing the determinants and role of safety climate. *Journal of safety research*, *35*(1), 81-90.

Dickson, M. W., Resick, C. J., and Hanges, P. J. (2006). When organizational climate is unambiguous, it is also strong. *Journal of applied psychology*, *91*(2), 351.

Fang, D., Chen, Y., and Wong, L. (2006). Safety climate in construction industry: A case study in Hong Kong. *Journal of construction engineering and management*, *132*(6), 573-584.

Feng, Y., Teo, E. A. L., Ling, F. Y. Y., and Low, S. P. (2014). Exploring the interactive effects of safety investments, safety culture and project hazard on safety performance: An empirical analysis. *International journal of project management*, *32*(6), 932-943.

Flin, R. (2007). Measuring safety culture in healthcare: A case for accurate diagnosis. *Safety science*, *45*(6), 653-667.

Gillen, M., Baltz, D., Gassel, M., Kirsch, L., and Vaccaro, D. (2002). Perceived safety climate, job demands, and coworker support among union and nonunion injured construction workers. *Journal of safety research*, *33*(1), 33-51.

Ginsburg, L., Gilin, D., Tregunno, D., Norton, P. G., Flemons, W., and Fleming, M. (2009). Advancing measurement of patient safety culture. *Health services research*, *44*(1), 205-224.

Glendon, A. I., and Litherland, D. K. (2001). Safety climate factors, group differences and safety behaviour in road construction. *Safety science*, *39*(3), 157-188.

Goldenhar*, L., Williams, L. J., and G. Swanson, N. (2003). Modeling relationships between job stressors and injury and near-miss outcomes for construction labourers. *Work and stress*, *17*(3), 218-240.

Guldenmund, F. W. (2000). The nature of safety culture: a review of theory and research. *Safety science*, *34*(1), 215-257.

Hair J, Anderson RE, Tatham RL, Black WC. (1995). Multivariate data analysis. 4th ed. New Jersey: Prentice-Hall Inc.

Hale, A. (2009). Why safety performance indicators?. *Safety science*, *47*(4), 479-480.

Haukelid, K. (2008). Theories of (safety) culture revisited—An anthropological approach. *Safety science*, *46*(3), 413-426.

Hofmann, D. A., and Stetzer, A. (1998). The role of safety climate and communication in accident interpretation: Implications for learning from negative events. *Academy of management journal*, *41*(6), 644-657.

Hu, L., and Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling*, *6*(1), 1-55.

Johnson, S. E. (2007). The predictive validity of safety climate. *Journal of safety research*, *38*(5), 511-521.

Kath, L. M., Magley, V. J., and Marmet, M. (2010). The role of organizational trust in safety climate's influence on organizational outcomes. *Accident analysis and prevention*, *42*(5), 1488-1497.

Keenan, V., Kerr, W., and Sherman, W. (1951). Psychological climate and accidents in an automotive plant. *Journal of applied psychology*, *35*(2), 108.

Kongsvik, T., Almklov, P., and Fenstad, J. (2010). Organisational safety indicators: some conceptual considerations and a supplementary qualitative approach. *Safety science*, *48*(10), 1402-1411.

Mearns, K., Whitaker, S. M., and Flin, R. (2003). Safety climate, safety management practice and safety performance in offshore environments. *Safety science*, *41*(8), 641-680.

Milijic, N., Mihajlovic, I., Strbac, N., and Zivkovic, Z. (2013). Developing a questionnaire for measuring safety climate in the workplace in Serbia. *International journal of occupational safety and ergonomics*, *19*(4), 631-645.

Mohamed, S. (2002). Safety climate in construction site environments. *Journal of construction engineering and management*, *128*(5), 375-384.

Morrow, P. C., and Crum, M. R. (2004). Antecedents of fatigue, close calls, and crashes among commercial motor-vehicle drivers. *Journal of safety research*, *35*(1), 59-69.

Mosher, G. A. (2011). *Measurement and analysis of the relationship between employee perceptions and safety and quality decision-making in the country grain elevator*. (Doctoral dissertation, Iowa State University).

Mosher, G. A., Keren, N., Freeman, S. A., & Hurburgh, C. R. (2013). Measurement of worker perceptions of trust and safety climate in managers and supervisors at commercial grain elevators. *Journal of agricultural safety and health*, *19*(2), 125-134.

Nahrgang, J.D., Morgeson, F.P., Hofmann, D.A., 2008. Predicting safety performance: a meta-analysis of safety and organizational constructs. In: Presented at the Annual Meeting of the Society for Industrial and Organizational Psychology, San Francisco, April.

Neal, A., Griffin, M. A., and Hart, P. M. (2000). The impact of organizational climate on safety climate and individual behavior. *Safety science*, *34*(1), 99-109.

Neal, A., and Griffin, M. A. (2006). A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. *Journal of applied psychology*, *91*(4), 946.

O'Reilly, C. A., and Chatman, J. A. (1996). Culture as social control: Corporations, cults, and commitment.

Ostroff, C., Kinicki, A. J., and Tamkins, M. M. (2003). *Organizational culture and climate*. John Wiley and Sons, Inc.

Payne, S. C., Bergman, M. E., Beus, J. M., Rodríguez, J. M., and Henning, J. B. (2009). Safety climate: Leading or lagging indicator of safety outcomes?. *Journal of loss prevention in the process industries*, *22*(6), 735-739.

Probst, T. M. (2004). Safety and insecurity: exploring the moderating effect of organizational safety climate. *Journal of occupational health psychology*, *9*(1), 3.

Reiman, T., Pietikäinen, E., and Oedewald, P. (2010). Multilayered approach to patient safety culture. *Quality and safety in health care*, qshc-2008.

Reiman, T., and Pietikäinen, E. (2012). Leading indicators of system safety–monitoring and driving the organizational safety potential. *Safety science*, *50*(10), 1993-2000.

Saari, J. (1990). On strategies and methods in company safety work: From informational to motivational strategies. *Journal of occupational accidents*, *12*(1-3), 107-117.

Salminen, S., Saari, J., Saarela, K. L., and Räsänen, T. (1993). Organizational factors influencing serious occupational accidents. *Scandinavian journal of work, environment and health*, 352-357.

Schneider, B., and Reichers, A. E. (1983). On the etiology of climates. *Personnel psychology*, *36*(1), 19-39.

Schneider, B., Salvaggio, A., and Subirats, M. (2002). Climate strength: A new direction for climate research. *Journal of applied psychology*, 87, 220–229.

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of educational research*, *99*(6), 323-338.

Simpson, S. A. (2015). *A study of safety climate and employees' trust of their organizational leadership in university research laboratories* (Doctoral dissertation, Iowa State University).

Smith, G. S., Huang, Y. H., Ho, M., and Chen, P. Y. (2006). The relationship between safety climate and injury rates across industries: The need to adjust for injury hazards. *Accident analysis and prevention*, *38*(3), 556-562.

Stetzer, A., and Hofmann, D. A. (1996). Risk compensation: Implications for safety interventions. *Organizational behavior and human decision processes*, *66*(1), 73-88.

Tabachnick BG, Fidell LS. (2007). Using Multivariate Statistics. Boston: Pearson Education Inc.

Thompson, B. (2004). *Exploratory and confirmatory factor analysis: Understanding concepts and applications*. American Psychological Association.

Varonen, U., and Mattila, M. (2000). The safety climate and its relationship to safety practices, safety of the work environment and occupational accidents in eight wood-processing companies. *Accident analysis and prevention*, *32*(6), 761-769.

Vinodkumar, M. N., and Bhasi, M. (2009). Safety climate factors and its relationship with accidents and personal attributes in the chemical industry. *Safety science*, *47*(5), 659-667.

Williams, B., Onsman, A., & Brown, T. (2010). Exploratory factor analysis: A five-step guide for novices. *Australasian journal of paramedicine*, *8*(3).

Wu, T. C., Chen, C. H., and Li, C. C. (2008). A correlation among safety leadership, safety climate and safety performance. *Journal of loss prevention in the process industries*, *21*(3), 307-318.

Zohar, D. (1980). Safety climate in industrial organizations: theoretical and applied implications. *Journal of applied psychology*, *65*(1), 96.

Zohar, D. (2000). A group-level model of safety climate: testing the effect of group climate on microaccidents in manufacturing jobs. *Journal of applied psychology*, *85*(4), 587.

Zohar, D. (2002). The effects of leadership dimensions, safety climate, and assigned priorities on minor injuries in work groups. *Journal of organizational behavior*, *23*(1), 75-92.

Zohar, D. (2002). Modifying supervisory practices to improve subunit safety: a leadership-based intervention model. *Journal of applied psychology*, *87*(1), 156.

Zohar, D., and Luria, G. (2003). The use of supervisory practices as leverage to improve safety behavior: A cross-level intervention model. *Journal of safety research*, *34*(5), 567-577.

Zohar, D., and Luria, G. (2004). Climate as a social-cognitive construction of supervisory safety practices: scripts as proxy of behavior patterns. *Journal of applied psychology*, *89*(2), 322.

Zohar, D., and Luria, G. (2005). A multilevel model of safety climate: cross-level relationships between organization and group-level climates. *Journal of applied psychology*, *90*(4), 616.

Zohar, D. (2008). Safety climate and beyond: A multi-level multi-climate framework. *Safety science*, *46*(3), 376-387.

Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. *Accident analysis and prevention*, *42*(5), 1517-1522.

CHAPTER 4. A QUALITATIVE INVESTIGATION OF SAFETY CLIMATE PERCEPTIONS IN TWO INDUSTRIES

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Introduction

Safety climate is commonly measured using questionnaire surveys whose data are often reduced to exploratory or confirmatory factors or sub-scales that can be correlated to some dependent or criterion variable such as safety-related behavior or injuries (Kongsvik, Almklov, and Fenstad, 2010). Most common are analysis of these surveys through Exploratory Factor Analysis (EFA), which seeks to uncover the underlying structure of a relatively large set of variables. EFA is a technique within factor analysis whose overarching goal is to identify the underlying relationships between measured variables. Often used in conjunction with Reliability Analysis to determine the internal consistency of the survey questions, these studies have identified various factors to explain safety climate perceptions in the industries or facilities in which they were deployed.

One of the most often cited studies was carried out by Zohar (1980) who examined 20 manufacturing facilities in Israel across a variety of industries. Utilizing a survey instrument consisting of 40 items, the results of analysis concluded that two primary factors – management attitudes about safety and management perceptions regarding the relevance of safety in general production processes explained safety climate perceptions. Furthermore, the perception of positive safety climate among the employees was correlated with positive safety performance according to safety inspectors (Zohar, 1980).

Further studies carried out since Zohar's 1980 study have used survey instruments which can in many ways trace their roots back to the original 40-item survey. The assessment of safety climate has been carried out in a variety of industries such as the manufacturing sector (Christian *et al.*, 2006; Clarke, 2006; Johnson, 2007; Zohar, 1980), the construction sector (Choudhry, Fang, and Lingard, Cooke, and Blismas 2009; Fang, Chen, and Wong, 2006; Pousette, Larsson, and Törner, 2008; Lingard, Cooke, and Blismas, 2010; Meliá *et al.,* 2008; Shen *et al.,* 2015; Zhou, Fang, and Wang, 2008; Zou and Sunindijo, 2013), as well as various other occupational sectors such as the energy sector (O'Conner *et al.*, 2011); hospitals (Singer *et al.*, 2009); oil and gas exploration (Skogdalen, Utne, and Vinnem, 2011); and the chemical industry (Vinodkumar and Bhasi, 2009).

The quantitative data gathered for the research study discussed in this paper was gathered from two sources – agricultural bulk commodity storage/handling facilities, and university research laboratories – industry segments which have not had the same frequency of safety climate research performed as in other industry segments, as well as lacking repeated study of safety climate. The data gathered from these two sources utilized survey instruments which were derivatives of the Zohar Safety Climate Questionnaire (ZSCQ), which was developed by Zohar and Luria (2005) to assess safety climate perceptions at the organizational level (management perceptions) as well as the group level (supervisor perceptions). Specifically, the data used for the quantitative portion of this research study built upon previous work by Mosher (2011, 2013) and Simpson (2015) who utilized the ZSCQ in their studies to attempt to assess matters of trust in organizations (Mosher, 2011).

Data from the Mosher (2011) study 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". Following the analytical methodology seen in previous research studies, the data were examined for suitability to fit a model through exploratory factor analysis, an initial model fit to determine which variables cross loaded on more than one principal factor, subsequent fitting of reduced models to eliminate cross loading, and the calculation of goodness-of-fit statistics and a reliability analysis. Results of the analysis indicated two principal factors, named *Supervisor Involvement in Safety* and *Management Commitment to Safety* and the resulting factors had high Cronbach alpha values ($a \geq 0.90$). In addition to the ZSCQ data, the Mosher (2011) study also collected demographic data from its participants regarding age range, length of tenure at organization, length of tenure with their supervisor, education level, self-assessment of fair pay, and self-assessment of overall job satisfaction, using a Likert-scaled questionnaire. These data were analyzed using Analysis of Variance (ANOVA) comparing the categorical data for each respondent to their overall safety climate score as the dependent variable and it was discovered that two variables *Fair Pay* and *Job Satisfaction* were statistically significant at the $p<0.05$ level, thus these variables were carried forward as having potential influence on overall safety climate perceptions.

Data from the Simpson (2015) study consisted of responses from 109 participants on a 36-item survey, each item Likert-scaled from 1 to 5, with 1 indicating "Strongly Agree" and 5 indicating "Strongly Disagree". Following the analytical methodology observed in previous research studies, the data were examined for suitability to fit a model through exploratory factor analysis, an initial model fit to determine which variables cross loaded on more than one principal factor, subsequent fitting of reduced models to eliminate cross loading, and the calculation of goodness-of-fit statistics and a reliability analysis. Results of the analysis indicated four principal factors, named *Supervisor Communication Reliability, Positive Safety Actions, Supervisor Dependability, and Supervisor Consistency* by the researcher based on which survey questions loaded on which particular factor and what the major theme of those questions was. The resulting factors had high Cronbach's alpha values ($a \geq 0.90$) for *Supervisor Communication Reliability* and *Positive Safety Actions,* acceptable Cronbach's alpha value ($a \geq 0.70$) for *Supervisor Personal Stability,* and questionable Cronbach's alpha value ($a \geq 0.60$) for *Supervisor Dependability*. In addition to the ZSCQ data, the Simpson 2015 study also collected demographic data from its participants regarding age range, length of tenure at organization, length of tenure with their supervisor, education level, self-assessment of fair pay, and self-assessment of overall job satisfaction, using a Likert-scaled questionnaire. These data were analyzed using Analysis of Variance (ANOVA) comparing the categorical data for each respondent to their overall safety climate score as the dependent variable and it was discovered that no variables were statistically significant at the $p<0.05$ level.

The results of these two analyses further confirm that factors related to organizational-level and group-level constructs are present in the assessment of perceptions of safety climate as has been demonstrated in previous studies (Ajslev *et al*., 2017; Flin *et al*., 2000; Liu *et al*., 2015; Milijic *et al*., 2013; Zohar, 1980, 2000, 2003, 2010; Zohar and Luria, 2005). Further, the results of these analyses agree with previous studies' findings when looking at which survey item questions grouped to particular factors, showing that previously identified constructs of *safety performance* (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 compliance and participation in safety programs* (Clarke, 2006; Nahrgang, Morgeson, and Hofmann, 2008), *workplace accidents and injuries* (Stetzer and Hofmann, 1996; Probst, 2004), and human aspects of safety climate, such as *management attitudes and communication* (Kath, Magley, and Marmet, 2010), can be thought of as leading indicators of safety. Despite this validity, researcher attention is needed towards theoretical and conceptual issues (Zohar, 2010). Kongsvik, Almklov, and Fenstad (2010) assert that most studies have used one of three approaches to establish the relationship between safety climate and safety performance 1) Climate factors are cross-sectional correlated with subjective measures of safety performance, typically within the same questionnaire (e.g. Goldenhar, Williams, and Swanson, 2003), 2) Climate factors are longitudinally correlated with subjective measures of safety performance, that is safety climate is measured at one point in time and subjective measures of safety performance are taken at some later point (e.g. Pousette *et al*., 2008), 3) Climate factors are correlated with objective measures of safety performance such as long-term injury (LTI) rates, frequencies of near misses (e.g. Cooper and Phillips, 2004).

While a much smaller proportion of the published research than quantitative studies, qualitative research as well as the data it collects, could uncover unknown occupational hazards and allow for the possibility of creating new indicators to measure safety performance (Kongsvik, Almklov, and Fenstad, 2010). The literature reviewed for this study indicated that even when researchers are attempting to assess the role of "psycho-social" factors such as social and supervisor support (Sampson, DeArmond, and Chen, 2014), quality of job-related and non-job-related communications (Sampson, DeArmond, and Chen, 2014), workplace obstacles such as safety uncertainty (Sampson, DeArmond, and Chen, 2014), influence at work (Tholén, Pousette, and Törner, 2013), sense of community (Tholén, Pousette, and Törner, 2013), social support (Tholén, Pousette, and Törner, 2013), and others – the analytical methodology employed was quantitative. According to Kongsvik, Almklov, and Fenstad, (2010), some aspects of organizational safety are harder to quantify. While a researcher could measure that one employee does not receive sufficient information from another employee, it is more difficult to measure the quality and content of the communication.

This research study sought to address the apparent gap in the knowledge base by utilizing both quantitative and qualitative data collection and analysis methodologies to deepen the understanding of the results collected – to not only understand that a safety climate influencing factor exists, but to understand to what degree it influences and how that factor is perceived by the workers affected by it. Kongsvik, Almklov, and Fenstad (2010) suggest: "*A more basic issue is to what extent organizational safety is within the reach of indicators and whether it is a phenomenon that can be factorized, as can be found in both the safety climate and risk analyses traditions. If one takes a more holistic view, which would stress the interrelations between the factorized entities, this remains problematic. Still, both the traditions have spurred much relevant safety effort of great value"* (pg 1410). This emphasizes the need for studies which not only quantify those things that can be quantified but assesses the relationship between factors which could be considered as measures of behavior, perceptions, thoughts, and feelings, and how they influence overall safety climate perception. Reflecting on 30 years of his own research as well as the research of others, Zohar (2010) stated *"...we have achieved an enormous task of validating safety climate as a robust leading indicator or predictor of safety outcomes across industries and countries. The time has therefore come for moving to the next phase of scientific inquiry in which constructs* *are being augmented by testing its relationships with antecedents, moderators and mediators, as well as relationships with other established constructs"* (pg 1521).

Methods

This research sought to examine safety climate through a mixed-methods approach in an attempt to help address the shortage of such bi-analytic studies, and was driven by the following research questions:

1. If gaps in the results of quantitative measures of safety climate are identified, can these gaps be closed with the addition of a qualitative method to supplement the data collection?
2. What constructs of safety climate not adequately measured by quantitative safety climate survey instruments are revealed or uncovered through employee narrative inquiry?

Using the results of the quantitative analyses from both the agricultural bulk commodity storage/handling facilities and the university research laboratories, the identified factors were used as the basis for formulating questions to be used in the collection of narratives from a small random sample of employees from each industry segment. These 8 factors are briefly described in terms of how they are conceptualized by the researcher, and the narrative collection question formulated to capture data related to how respondents perceive the particular factor.

Factor 1(agricultural bulk commodity storage/handling – from (Mosher, 2011) data) – *Supervisor Involvement in Safety*: To what extent, does the perception by employees of his/her supervisor being actively involved in the safety program(s) of the facility either through direct action or leadership decisions, affect the employee's overall perception of the safety climate in the workplace? Question 1 - "*Please describe in what way you feel your supervisor is involved in fostering a positive safety climate in your facility."*

Factor 2 (agricultural bulk commodity storage/handling – from (Mosher, 2011) data)– *Management Commitment to Safety:* To what extent, does the perception by employees of his/her senior management team demonstrating their commitment to improving safety in the workplace through direct actions or management decisions, affect the employee's overall perception of safety climate in the workplace? Question 2 - *"Please describe in what way you feel upper level or senior management in your facility is committed to fostering a positive safety climate."*

Factor 3 (university research laboratories – from (Simpson, 2015) data) - *Supervisor Communication Reliability:* To what extent, does the perception that a supervisor communicates in an open, honest, and consistent manner to his/her employees affect perceptions of safety climate? Question 3 - *"Please describe how the reliability of a supervisor's communication influences your perception of safety climate. i.e. a supervisor says the same thing from one time to the next or says the same things to different people or levels of the organization"*

Factor 4 (university research laboratories – from (Simpson, 2015) data)– *Positive Safety Actions:* 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? Question 4 - *"Please describe in what ways positive safety actions taken by employees or supervisors have an effect on the overall safety climate of the organization."*

Factor 5 (university research laboratories – from (Simpson, 2015) data)– *Supervisor Dependability:* 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? Question 5 - *"Please describe in what way the dependability of a supervisor (either through things they say or things they do) influence the overall safety climate of the organization."*

Factor 6 (university research laboratories – from (Simpson, 2015) data)– *Supervisor Personal Stability:* To what extent, do perceptions of the emotional and personality stability of a supervisor by his/her employees affect perception of safety climate? Question 6 - *"Please describe in what way the stability of a supervisor's personality (acts in a consistent and predictable manner, responds appropriately to situations) influence the overall safety climate of the organization."*

Factor 7 (agricultural bulk commodity storage/handling – from (Mosher, 2011) demographic questionnaire data)– *Job Satisfaction:* To what extent, does an employee's feeling of personal/emotional satisfaction with his/her job (responsibility level, duties performed, relationship with co-workers and supervisory personnel, etc.) affect perception of safety climate? Question 7 - *"Do you believe that your personal level of job satisfaction has an impact on the safety climate of the facility you work in?"*

Factor 8 (agricultural bulk commodity storage/handling – from (Mosher, 2011) demographic questionnaire data)– *Fair Pay:* To what extent, does an employee's feeling of being adequately or fairly financially compensated for their labors affect perception of safety climate? Question 8 - *"Do you believe that your personal feeling regarding how fairly you are paid for your work has an impact on the safety climate of the facility you work in?"*

In addition to these 8 narrative collection questions, a preliminary question *"How would you personally define the term "safety climate"?* was asked in order to "frame" the subsequent questions so that as each respondent answered them, that respondent was answering the questions in regard to their perception of what safety climate is. This was done not only to ground all the narrative collection questions in a common theme, but also to reduce the amount of leading for the questions (e.g. asking respondents to answer questions about personal perceptions of a construct term "safety climate" given a pre-existing definition rather than allowing respondents to conceptualize safety climate in their own words and answer questions about the factors that might influence their perceptions).

The narrative collection was carried out via online survey created in Qualtrics®. A message was sent to a list of fifteen individuals across the two industries of interest extending an invitation to participate in this research study. Further, the message asked the contacts to further extend the invitation to the supervisors and workers under them so as to gather as large a pool of participants as possible. While unknown precisely what number of potential participants was, a total of twelve individuals completed the online survey. No identifying questions were asked to collect demographic information from the respondents. The following section describes each question asked in the narrative collection, the initial results of the analysis, provides the responses in a tabular format, and discusses the themes uncovered during the analysis.

Results

Results of the narrative collection portion of data collection revealed that across the respondents, most of the data points indicate that a particular factor/variable has an impact on a respondent's personal perception or overall perception of safety climate in the workplace.

Question 1 - *"How would you personally define the term safety climate"* - 10 of 12 respondents indicated they had at least an intuitive sense of what is meant by "safety climate". Of the 2 remaining respondents, one respondent failed to answer the question entirely while the other respondent typed "*poorly*" for their answer. Examples from the data are shown in Table 1.

Table 1. Responses to narrative question 1

Respondent	Q: How would you personally define the term "safety climate"?
1	Safety climate depends on the overall safety of the facility and how employees interact with safety.
2	Feelings and attitudes of all levels of the organization with regards to working safely and protecting workers on the job.
3	The attitude of management and workers toward performing their jobs with personal and mechanical safety in mind.
4	poorly
5	It is the sense a person has about the safety of the workplace and how serious safety is taken by the people that work there
6	Whether or not people in the lab work safely and follow the protocols as well as the overall attitude towards safety in general.
7	How safe people feel while at work and their attitude about safety and safety rules
8	The degree of safety in a particular place or venue.
9	The overall sense of how safe the facility is and how people feel about safety and safety rules
10	The degree in which safety of the person is taken into consideration.
11	How safe is the working environment?
12	(no answer provided by respondent)

Repeated words used in these responses include "feel/feelings", "attitude(s)", and "sense". These repeated words indicate to the researcher that these constructs are important to the respondents and warrant further scrutiny. These repeated words also align with the definition of safety climate put forth by Zohar (1980) - "*a summary of molar perceptions that employees share about their work environments"* (pg 96) as well as with Denison (1996) who defined safety climate - "*Climate refers to a situation and it's link to thoughts, feelings and behaviors of organizational members*" (pg 644).

Question 2 - "*Please describe in what way you feel your supervisor is involved in fostering a positive safety climate in your facility."* - All respondents indicated their own ideas of how supervisors *should be* involved in fostering a positive safety climate, or they had first-hand experience in their workplace with a supervisor *who was/is* involved in fostering a positive safety climate. Examples from the data are shown in Table 2.

Table 2. Responses to narrative question 2

Respondent	Q: Please describe in what way/s you believe a supervisor is involved in fostering a positive safety climate in the workplace.
1	Our boss never lets anything go down that would cause injuries. This includes product safety, where she makes certain everybody who works on the line performs regular checks.
2	Supervisors are leaders and should demonstrate how things should be done safely yet are also responsible for enforcing safety at work.
3	His/her attitude toward the safety of his/her subordinates. For instance, are they proactive, reactive, or antagonistic toward safety.
4	A supervisor should advocate for the safety of the people who work under them
5	Good supervisors are liaisons between the workers and senior management or regulatory/enforcement personnel
6	By leading through example. If a supervisor follows the safety rules they want employees to follow, it builds trust.
7	The supervisor should set the example and explain why safety rules are in place and enforce them fairly to the employees
8	A supervisor can implement safety procedures to those in his group, and direct subordinates to behave in appropriate manners.
9	If the supervisor values safety, they can help influence how workers feel and behave
10	By instructing individuals in the laboratory to take measures to keep themselves safe, what to do when an accident has occurred, and discussion of hazards prior to the initiation of an experiment or procedure.
11	They are primarily responsible to make sure rules from EHS, OSHA, etc. are followed.
12	Protection of rights and enforcement of rules

Repeated words/phrases in these responses include "supervisor should", as well as verbs describing the actions of a supervisor such as "make certain", "follows", "enforces", "leading", "set the example", "explain", "instruct", and "implement". These repeated words/phrases and action words or phrases indicate that a supervisor's direct involvement in the safety programs of a workplace has an influence on the safety climate perceptions of the workers under he or she. This aligns with findings of previous studies which identified aspects influencing safety climate such as management attitudes and communication (Kath, Magley, and Marmet, 2010), CEOs' and managers' safety commitment (Wu, Chen, and Li, 2008), safety leadership (Conchie, Moon, and Duncan, 2013; Du and Sun, 2012; Eid *et al*., 2012; Kapp, 2012; Künzle, Kolbe, and Grote, 2010; Liou, Yen, and Tzeng, 2008; Lu and Yang, 2010), and safety management (DeJoy, 2010; Hale *et al*., 1997; Hale *et al*., 2010; Hsu, Li, and Chen, 2010; Hurst *et al*., 1996; Hurst, 1997; Luria and Morag, 2012; Mosher *et al*., 2013).

Question 3 - "*Please describe in what way you feel upper level or senior management in your facility is committed to fostering a positive safety climate."* - 11 respondents indicated that the senior-level personnel in their organization were currently committed to fostering a positive safety climate or provided suggestions of how senior-level personnel could demonstrate their commitment. One respondent answered, "I don't know". Examples from the data are shown in Table 3.

Table 3. Responses to narrative question 3

Respondent	Q: Please describe in what ways you believe upper level or senior management in the workplace is committed to fostering a positive safety climate.
1	Well they send inspectors around multiple times a year to make sure we are following safety procedures.
2	Senior managers try to reduce potential liability and financial loss, so they have a motivation through money to keep the workplace safe
3	Are they proactive or antagonistic in making the workplace safe for their employees? Do they listen to the concerns of the employees? Or are they only active when forced to be due to the union, for instance?
4	Upper level managers should attend more safety meetings and relay information about the impact our safety programs are having.
5	Licenses and permits are in the name of the senior personnel and unsafe conditions can put those licenses and permits in jeopardy which would affect all people working under them
6	Our senior manager notifies us about inspections and is present when they happen to answer questions we might not be able to answer by ourselves.
7	Upper management sets policy about safety and gives responsibility to supervisors to make sure safety rules are followed in the workplace
8	Senior level management are most concerned about avoiding liability. To this end they have an incentive to adopt prudent safety measures.
9	Upper level makes policies that supervisors carry out. There needs to be good communication
10	I believe they are very committed to keeping the labs a safe environment.
11	I don’t know
12	Embrace changes and enforce safety rules

The responses collected display multiple use of phrases or words associated with “liability”, as well as sharing some of the same shared words or phrases as in Question 2’s responses, that of “notifies”, “sets policy”, “makes policy”, and “enforce safety rules”. Similar to Question 2, these results align with findings of previous studies which identified aspects influencing safety climate such as management attitudes and communication (Kath, Magley, and Marmet, 2010), CEOs’ and managers’ safety commitment (Wu, Chen, and Li, 2008), safety leadership (Conchie, Moon, and Duncan, 2013; Du and Sun, 2012; Eid *et al*., 2012; Kapp, 2012; Künzle, Kolbe, and Grote, 2010; Liou, Yen, and Tzeng, 2008; Lu and Yang, 2010), and safety management (DeJoy, 2010; Hale *et al*., 1997; Hale *et al*., 2010; Hsu, Li, and Chen, 2010; Hurst, 1997; Luria and Morag, 2012; Mosher *et al*., 2013).

Question 4 - "*Please describe how the reliability of a supervisor's communication influences your perception of safety climate. i.e. a supervisor says the same thing from one time to the next or says the same things to different people or levels of the organization"* - 11 respondents indicated that the reliability/consistency of a supervisor's communication had an impact on safety climate. One respondent answered "no". Examples from the data are shown in Table 4.

Table 4. Results of narrative question 4

Respondent	Q: Please describe how the reliability of a supervisor's communication influences safety climate. For example, does a supervisor saying the same thing from one time to the next or saying the same things to different people or levels of the organization influence your perception of safety climate?
1	One manager might say to do things one way and another might say to do things a different way, but if there is a discontinuity they make a note to check back with higher authority and resolve the problem. Two different managers don't say different things for very long before they get things sorted out. All the managers are usually on the same page about safety.
2	If a supervisor says different things to different people about the same issue it creates confusion and this impacts work.
3	Yes indeed. For example, I once brought a safety issue to the attention of management and got in trouble for it. Not much later someone was injured by the equipment I raised the concern about. I communicated effectively, but management misunderstood my relationship to the problem and criticized me for it.
4	Favoritism in the workplace is damaging to the relationship other workers have with a supervisor. Some supervisors play favorites and some people are able to get away with things that would get some other people fired.
5	Knowing how a supervisor will reply from one time to the next when a safety concern is brought up is necessary to build trust and keep workers willing to report those things they notice on the job
6	I realize that what a supervisor talks about with their boss isn't the same as what they talk about with us, but we can only hope the message about safety is the same.
7	Yes. If a supervisor is not consistent in what they say or if they say different things to different levels of people, it makes us feel like the priority of safety is avoiding regulators instead of protecting us at work
8	It is not necessarily effective for a supervisor to communicate the same things in the same manner to everyone under his influence. The supervisor should gauge how each individual will react, and communicate accordingly. Not everyone needs a stern warning. But some do.

Table 4. (continued)

9	If communication is reliable, employees are more likely to trust what is being said and will be likely to follow safety rules
10	(no answer provided)
11	This seems very important. Repeating the same thing is not very effective if it's not understood, even though consistency is a good thing. We try to use SOPs to standardize and discuss lab safety issues regularly to address questions in my lab.
12	Consistency in message to all parties is critical

A recurring theme in the responses from Question 4 appears to be the link between consistent communication from the supervisor and the impact it has on trust of the employees. This theme aligns with the findings of previous studies (Kath, Magley, and Marmet., 2010; Luria, 2010) which identified organizational trust as partially explaining safety climate.

Question 5 - "*Please describe in what ways positive safety actions taken by employees or supervisors have an effect on the overall safety climate of the organization.*" All respondents indicated what kinds of actions could be taken at work to foster a positive safety climate or were able to recount examples from their own life demonstrating how positive safety actions had helped to foster a positive safety climate in the workplace. Examples from the data are shown in Table 5.

Table 5. Responses from narrative question 5

Respondent	Q: Please describe in what ways positive safety actions taken by employees or supervisors have an effect on the overall safety climate of the organization.
1	Communication is rapid and definitive. If somebody doesn't know what to do about some safety matter, we know who WILL know and we get it resolved as soon as possible.
2	Having an environment where you are encouraged to point out safety concerns and correct them or get them corrected helps to build a good environment and workers feel involved in safety at work

Table 5. (continued)

3	Again, is management proactive in determining and correcting safety issues, or do they only respond to concerns raised, or do they resist making any changes (Investing money) in things that will make the workplace safer?
4	When safety feels like something positive instead of punitive it gives people a sense that safety is important, and all people can take part in it and make it better
5	A supervisor that points out when we do something right and safely makes us feel as though we are doing the right things. Many supervisors only say something when there is a problem, and that makes people want to recoil from them
6	Our supervisor encourages us to bring up safety concerns in our weekly meetings and we go through them as a group to correct them immediately or generate ideas of how to fix them. It makes us feel involved and that our supervisors and management care about our safety
7	If people show they are involved or can be involved in how safety is applied at the workplace, we feel like it's something we have a say in instead of something that is done to us. Plus, if people can be involved, we feel like we are more connected to safety overall
8	It depends on the extent. Minor things--e.g., picking up a paperclip off the floor--likely have a minor impact. Major things--e.g., reporting an electrical outlet that appears to be shorted out--may have a major impact.
9	If you see people doing safe things, it makes others want to do the same. Kind of a peer pressure.
10	Recognizing and encouraging safe behaviors and persons that demonstrate these behaviors.
11	It depends on what is meant by "positive safety actions". If this can be inferred to be any positive act to prevent a safety issue, then it's very important that everyone is involved and brings up any potential issues so that safety can be maintained.
12	Acceptance, transparency and standing up for the rights of those under your supervision

Repeated words in the responses include "encouraging" and "involved". Across the responses to this question, a theme of positive involvement appears to emerge. The responses to this question and the emergent theme align with the findings of previous studies which identified factors such as organizational social support (Conchie, Moon, and Duncan, 2013; Huang, You, and Tsai, 2012), and safety action reciprocity (DeJoy *et al*., 2010) as being influential in explaining safety climate perceptions in the workplace.

Question 6 - *"Please describe in what way the dependability of a supervisor (either through things they say or things they do) influence the overall safety climate of the organization."* - 11 respondents provided examples demonstrating how the dependability of a supervisor helped to foster a positive safety climate, or how a supervisor being considered dependable could help improve safety climate. One respondent provided no answer. Examples from the data are shown in Table 6.

Table 6. Responses from narrative question 6

Respondent	Q: Please describe in what ways the dependability of a supervisor (either through things they say or things they do) influence the overall safety climate of the organization.
1	That's easy! Managers who are NOT dependable don't last long where I work. They usually weed themselves out.
2	When a supervisor or manager says they will take care of something, we need to know they will do what they say. If they don't, it hurts the trust we have with them and makes work more difficult
3	If something is brought to the attention of the supervisor, is it addressed promptly, or is it neglected due to forgetfulness or any other reason? The more unreliable the supervisor is in addressing safety issues, the less motivated the subordinates are in noticing and reporting safety issues.
4	Supervisors need to build relationships with the people under them, and being a dependable person through both words and actions is important to build that relationship as well as maintain it
5	It helps a great deal to know that when a supervisor says they will address something you've brought up to them that they will do what they say. If they don't we would be less likely to bring things up to them in the future and that might lead to safety issues being overlooked.
6	Not being able to count on a supervisor to do the right things or what they say they'll do makes it hard to work with them or for them
7	We need to know that if we have a safety concern that the supervisor will pay attention to it and take care of it. Also, we need to see fair treatment of people so that some people don't get away with breaking rules while others get in trouble for doing the same things
8	Subordinates may be more likely to listen and adhere to a dependable supervisor. Note: A "dependable" supervisor is not the same as a supervisor who communicates in a consistent manner from a few questions ago.
9	If you know how a supervisor will respond, you know what to expect and with safety you might be more willing to talk about safety issues with them.
10	I believe a supervisor greatly influences this behavior. If it is innate in the group because the leader is talking about it and demonstrating safe behaviors other will naturally follow. The same is true when leaders do not.
11	It's important to an extent but having a good protocol and common ground and frequent discussion to follow through consistently on the protocol is more important. Dependability of a supervisor to uphold safety SOPs and support staff in this way is important.
12	(no answer provided)

Responses to this question make frequent mention of communication and its importance, as well as the need for a supervisor to be "counted on" or "do what they say". From the responses to this narrative question, a theme of deeds matching words appears to emerge. The responses to this question and the emergent theme align with the findings of previous studies which identified safety leadership (Conchie, Moon, and Duncan, 2013; Du and Sun, 2012; Eid *et al*., 2012; Kapp, 2012; Künzle, Kolbe, and Grote, 2010; Liou, Yen, and Tzeng, 2008; Lu and Yang, 2010), organizational trust (Kath, Magley, and Marmet., 2010; Luria, 2010), and organizational social support (Conchie, Moon, and Duncan, 2013; Huang, You, and Tsai, 2012) as being influential to safety climate perceptions.

Question 7 - *"Please describe in what way the stability of a supervisor's personality (acts in a consistent and predictable manner, responds appropriately to situations) influence the overall safety climate of the organization."* - 11 respondents provided examples to explain how a supervisor's personality can or does affect the safety climate of a workplace. One respondent answered, "choose not to comment". Example data are shown in Table 7.

Table 7. Responses from narrative question 7

Respondent	Q: Please describe in what ways the stability of a supervisor's personality influences the overall safety climate of the organization.
1	Choose not to comment
2	Supervisors with unstable or volatile personalities are difficult to work with and there is either high employee turnover or if we are lucky the supervisor gets transferred someplace else.
3	When one doesn't know whether or not the supervisor will react hostile to a suggestion or concern, one tends to avoid risking interaction with such a supervisor.
4	Everyone has a bad day sometimes, but it's unacceptable to have a supervisor who is always overreacting to situations.
5	Knowing how a supervisor will react when you talk to them about a problem at work makes it easier to bring things to their attention.
6	When a supervisor has swings in their personality it's difficult to know how to interact with them and that impacts how employees do their jobs. Having a stable personality makes building and maintaining a working relationship much easier

Table 7. (continued)

7	If a supervisor is helpful one time and blows up the next, it makes it difficult to talk to them and we're less likely to want to bring things to their attention that need to be taken care of. We need to know how the supervisor will respond from one time to the next so we can trust them and have a good relationship with them
8	Supervisors who act consistent help create and build trust with workers and make working easier especially where safety is concerned
9	If you know a supervisor won't blow up if they see you do something wrong, you wont want to hide safety problems. Supervisors should have stable personalities
10	When supervisors are only concerned during times of inspection it does not encourage a safe climate.
11	This is critical. Juggling personal makes it hard to keep an eye on all safety issues, especially emerging ones. With all of the demands placed on PIs, it is a challenge to always know all of the potential safety issues and having personal to help watch and report issues and enforce policy is critical. It takes a team effort.
12	If they are not consistent, appearances are everything, if they waffle then others do not feel the message is consistent or real and they will not take a chance to express themselves.

Responses to this question, by and large, appeared to be slanted towards the negative, using words such as “unstable”, “volatile”, “unacceptable”, “blow up”, “overreacting”, etc. Previous studies have found that aspects of safety climate, such as management attitudes and communication, have an effect on organizational safety-related behaviors (Kath, Magley, and Marmet, 2010). Further research (Coyle-Shapiro and Kessler, 2000) indicates that employee perceptions of management meeting its obligations leads to both increased employee commitment, as well as trust in the organization (Robinson, 1996).

Question 8 - *“Do you believe that your personal level of job satisfaction has an impact on the safety climate of the facility you work in?”* - All respondents felt that their own level of satisfaction with the job has a definite impact on the safety climate of the workplace. This question garnered the second most verbose answers of the survey, with all respondents speaking of job satisfaction in terms of current employment situations or of previous jobs and doing so with multiple sentences. Examples from the data are shown in Table 8.

Table 8. Responses from narrative question 8

Respondent	Q: In what ways do you believe that your personal level of job satisfaction impacts the safety climate of the workplace?
1	I'm the kind of person who doesn't like to climb ladders, so it is a matter of personal interest to me to make sure things are safe at work.
2	Working a job you aren't satisfied with is stressful and it occupies your thoughts. This can impact safety if you are distracted thinking about how much you don't like your job and aren't engaged or paying attention and just trying to get done to go home
3	When one is satisfied, one is more concerned about the success of the company (which includes its safety atmosphere). When one is dissatisfied, one doesn't have the energy to care so much about safety issues.
4	Being able to enjoy work is important to reduce your stress. If you like your job and the people you work with, you'll want to do the right things to keep the atmosphere positive
5	Not only my personal satisfaction, but if others in the workplace aren't satisfied, there is a tension in the air and other people can pick up on that
6	If I don't like the job I have, I'm thinking about the new job I should get someplace else and I won't care much about safety where I am except for mine until I can leave for a new job that I will like better
7	If I like my job and the people I work with, I'm more likely to feel more invested in the safety of me and my coworkers. If other people feel the same, I think it improves the safety climate of the workplace
8	When I am more satisfied in a particular job, I tend to take greater care and thus be safer. OTOH, in some jobs I've loved I have simply been overwhelmed with work. In those jobs I'd be more likely to cut corners with respect to safety procedures.
9	If i like my job, i will stay there longer and feel connected to my coworkers and their safety as well as mine. Ill leave a job i don't like.
10	As a supervisor, I feel that my level of job satisfaction and concern over lab safety will greatly impact those that work with me.
11	I think happy workers will be more careful in what they do and less likely to make an error that could impact safety.
12	If I am not comfortable or feel threatened, morale will be low and I will not be dedicated towards positive outcomes, I won't care if they don't care about me.

Repeated words in the responses to this question include "satisfied" and "like", as well as a repeated line of thought talking about leaving or quitting a job the respondent is not satisfied with. Previous studies have identified a relationship between job satisfaction and safety climate (Flin *et al.,* 2000; Mearns, Whitaker and Flin, 2003; Neal and Griffin, 2004; Nielsen and Mearns, 2011; Siu, Phillips and Leung, 2004). The collected responses to these narrative questions appear to align with these previous studies' findings.

Question 9 - *"Do you believe that your personal feeling regarding how fairly you are paid for your work has an impact on the safety climate of the facility you work in?"* - 11 respondents felt that being paid fairly had an impact on safety climate in the workplace. It is interesting to note however, that in the narratives, the respondents spoke of being paid fairly in parallel with job satisfaction, and that if a person was not paid fairly for their work that they would be seeking employment elsewhere. One respondent answered "N/A, I am an unpaid intern". Examples from the data are shown in Table 9.

Table 9. Responses from narrative question 9

Respondent	Q: In what ways do you believe that your personal feeling of being paid fairly for your work has an impact on the safety climate of the facility you work in?
1	Doesn't matter. I'm not going to petulantly do my job poorly just because I don't think I'm being paid enough. If I really am convinced I'm not getting enough money, I'll go get a job somewhere else.
2	Workers feeling as though they aren't being fairly compensated leads to negative feelings about work in general and they will begin taking shortcuts and not giving their best effort. They will reduce their efforts and their attention to a level where they feel as though they aren't doing quite so much for no adequate compensation for their efforts.
3	One might reason that if the company is too cheap to pay fairly, they are too cheap to invest in appropriate safety measures, and therefore one might not bother to mention valid safety concerns.
4	Fair pay for the work I do helps me to like the job I am doing. If I have a positive attitude about my work, others likely do as well, and that overall positive attitude influences the safety climate at work.
5	Sometimes the most engaged people in day to day safety are the lowest paid people because they are trying to get raises or promotions and they see being really involved in safety as a way to get the attention of their supervisor and recommended for raises. It works sometimes.
6	Being paid fairly is important for a person's self esteem about their work and that impacts how they do their job, how they work with other people, and how engaged they are in trying to keep themselves and others safe at work.

Table 9. (continued)

7	If I feel like I'm paid fairly, I will like my job more, and I'll be more connected to the safety climate. If I don't think I'm paid fairly, I'll probably only work there temporarily and won't have the emotional connection to the workplace and safety climate would be less for me
8	I might take greater care of equipment and facilities in a job where I felt I was being fairly compensated. OTOH, if I was being underpaid I wouldn't stick around long.
9	If i feel unfairly paid, ill be looking for another job and wont feel connection with my job or coworkers. I wont be involved in the safety but will just go along with it.
10	N/A – I am an unpaid intern
11	This is a hard question to answer- it depends on the level of "fairness". I could see if someone was very underpaid that they might not feel it so important to take care of all of the fine details of their tasks which would include upholding safety policy
12	It's huge. If you are pleased with my work and my ethic, then it should mean something to you. If it does, then you should reward that behavior. If you don't repeatedly, which is consistent where I work, then you don't really care. Money should be first, but even attempts like free parking or additional leave would at least be interpreted as attempts to show appreciation.

The results of this particular narrative question are insightful because they indicate that an employee's perception of being paid fairly or adequately compensated for their efforts to have an influence on safety climate perceptions. There does not appear to be any clear link between pay, wages, or compensation and its effects on safety climate in the literature. However, the responses to this narrative question also appear to speak of fair pay in similar terms to the responses to the question asking about job satisfaction.

Overall, the results from the collection of narratives from the respondents align with results of previous research studies which found factors such as management attitudes and communication (Kath, Magley, and Marmet, 2010), CEOs' and managers' safety commitment (Wu, Chen, and Li, 2008), safety leadership (Conchie, Moon, and Duncan, 2013; Du and Sun, 2012; Eid *et al.*, 2012; Kapp, 2012; Künzle, Kolbe, and Grote, 2010; Liou, Yen, and Tzeng, 2008; Lu and Yang, 2010), and safety management (DeJoy, 2010; Hale *et al.*, 1997; Hale *et al.*, 2010; Hsu, Li, and Chen, 2010; Hurst *et al.*, 1996; Hurst, 1997; Luria and Morag, 2012; Mosher *et al.*, 2013), organizational trust (Kath, Magley, and

Marmet., 2010; Luria, 2010), safety action reciprocity (DeJoy *et al*., 2010), and job satisfaction (Flin *et al.,* 2000; Mearns, Whitaker and Flin, 2003; Neal and Griffin, 2004; Nielsen and Mearns, 2011; Siu, Phillips and Leung, 2004) to be influential or play a mediating role on safety climate perceptions. With 93.5% of the narratives collected in this study indicating that a factor/variable has an impact on a respondent's personal perception or overall perception of safety climate in the workplace, these results align with the results of previous studies which used quantitative measures to assess safety climate perceptions versus this study's qualitative measure.

One of the research questions asked about gaps within the quantitative measures. If gaps in the results of quantitative measures of safety climate are identified, can these gaps be closed with the addition of a qualitative method to supplement the data collection? The results of this qualitative approach to assessing safety climate do not disagree with the results of previous studies which used a quantitative assessment tool. While there was no new information gained from this study's approach that might indicate the quantitative assessment is lacking, the researcher believes using a two-prong approach to data collection has the ability for each type of collection to validate or invalidate the other, each case leading to an increase in knowledge regarding which factors influence safety climate and at what degree.

A recurring argument against the use of qualitative methods for organizational safety challenges is that they are time consuming and resource intensive (Kongsvik, Almklov, and Fenstad, 2010). However, it is important to investigate how safety climate is related to more generic psycho-social conditions in an organization in order to understand how psychological and social conditions are related to safety at work (Tholén, Pousette, and Törner, 2013). While perhaps not appropriate for every problem in organizational safety nor every assessment of safety climate due to the plethora of difficulties in carrying out research in a workplace environment, the use of both quantitative and qualitative methods of data collection and analysis provides a richness of data that allows for a more thorough understanding of the phenomena of safety climate in the workplace and how it may/can be impacted to meet organizational goals.

References

Ajslev, J., Dastjerdi, E. L., Dyreborg, J., Kines, P., Jeschke, K. C., Sundstrup, E., ... and Andersen, L. L. (2017). Safety climate and accidents at work: Cross-sectional study among 15,000 workers of the general working population. *Safety science*, *91*, 320-325.

Barbaranelli, C., Petitta, L., and Probst, T. M. (2015). Does safety climate predict safety performance in Italy and the USA? Cross-cultural validation of a theoretical model of safety climate. *Accident analysis and prevention*, *77*, 35-44.

Choudhry, R. M., Fang, D., and Lingard, H. (2009). Measuring safety climate of a construction company. *Journal of construction engineering and management*, *135*(9), 890-899.

Christian, M. S., Bradley, J. C., Wallace, J. C., and Burke, M. J. (2009). Workplace safety: a meta-analysis of the roles of person and situation factors.

Clarke, S. (2006). The relationship between safety climate and safety performance: a meta-analytic review.

Cooper, M. D., and Phillips, R. A. (2004). Exploratory analysis of the safety climate and safety behavior relationship. *Journal of safety research*, *35*(5), 497-512.

Conchie, S. M., Moon, S., & Duncan, M. (2013). Supervisors' engagement in safety leadership: Factors that help and hinder. *Safety science*, *51*(1), 109-117.

Coyle-Shapiro, J., & Kessler, I. (2000). Consequences of the psychological contract for the employment relationship: A large scale survey. *Journal of management studies*, *37*(7), 903-930.

DeJoy, David M., Lindsay J. Della, Robert J. Vandenberg, and Mark G. Wilson (2010). Making work safer: Testing a model of social exchange and safety management. *Journal of safety research* 41(2), 163-171.

Denison, D. R. (1996). What is the difference between organizational culture and organizational climate? A native's point of view on a decade of paradigm wars. *Academy of management review*, *21*(3), 619-654.

Du, X., & Sun, W. (2012). Research on the relationship between safety leadership and safety climate in coalmines. *Procedia engineering*, *45*, 214-219.

Eid, J., Mearns, K., Larsson, G., Laberg, J. C., & Johnsen, B. H. (2012). Leadership, psychological capital and safety research: Conceptual issues and future research questions. *Safety science*, *50*(1), 55-61.

Fang, D., Chen, Y., and Wong, L. (2006). Safety climate in construction industry: A case study in Hong Kong. *Journal of construction engineering and management*, *132*(6), 573-584.

Feng, Y., Teo, E. A. L., Ling, F. Y. Y., and Low, S. P. (2014). Exploring the interactive effects of safety investments, safety culture and project hazard on safety performance: An empirical analysis. *International journal of project management*, *32*(6), 932-943.
Flin, R., Mearns, K., O'Connor, P., and Bryden, R. (2000). Measuring safety climate: identifying the common features. *Safety science*, *34*(1), 177-192.

Goldenhar*, L., Williams, L. J., and G. Swanson, N. (2003). Modelling relationships between job stressors and injury and near-miss outcomes for construction labourers. *Work and stress*, *17*(3), 218-240.

Hale, A. R., Heming, B. H. J., Carthey, J., & Kirwan, B. (1997). Modelling of safety management systems. *Safety science*, *26*(1-2), 121-140.

Hale, A. R., Guldenmund, F. W., Van Loenhout, P. L. C. H., & Oh, J. I. H. (2010). Evaluating safety management and culture interventions to improve safety: Effective intervention strategies. *Safety science*, *48*(8), 1026-1035.

Hsu, Y. L., Li, W. C., and Chen, K. W. (2010). Structuring critical success factors of airline safety management system using a hybrid model. *Transportation research part E: logistics and transportation review*, *46*(2), 222-235.

Huang, C. C., You, C. S., & Tsai, M. T. (2012). A multidimensional analysis of ethical climate, job satisfaction, organizational commitment, and organizational citizenship behaviors. *Nursing ethics*, *19*(4), 513-529.

Hurst, N. W., Young, S., Donald, I., Gibson, H., and Muyselaar, A. (1996). Measures of safety management performance and attitudes to safety at major hazard sites. *Journal of loss prevention in the process industries*, *9*(2), 161-172.

Hurst, N. (1997). From research to practical tools—developing assessment tools for safety management and safety culture. *Journal of loss prevention in the process industries*, *10*(1), 63-66.

Johnson, S. E. (2007). The predictive validity of safety climate. *Journal of safety research*, *38*(5), 511-521.

Kapp, E. A. (2012). The influence of supervisor leadership practices and perceived group safety climate on employee safety performance. *Safety science*, *50*(4), 1119-1124.

Kath, L. M., Magley, V. J., and Marmet, M. (2010). The role of organizational trust in safety climate's influence on organizational outcomes. *Accident analysis and prevention*, *42*(5), 1488-1497.

Kongsvik, T., Almklov, P., and Fenstad, J. (2010). Organizational safety indicators: some conceptual considerations and a supplementary qualitative approach. *Safety science*, *48*(10), 1402-1411.

Künzle, B., Kolbe, M., & Grote, G. (2010). Ensuring patient safety through effective leadership behaviour: a literature review. *Safety science*, *48*(1), 1-17.

Larsson, S., Pousette, A., and Törner, M. (2008). Psychological climate and safety in the construction industry-mediated influence on safety behaviour. *Safety science*, *46*(3), 405-412.

Liou, J. J., Yen, L., and Tzeng, G. H. (2008). Building an effective safety management system for airlines. *Journal of air transport management*, *14*(1), 20-26.
Lingard, H. C., Cooke, T., and Blismas, N. (2010). Properties of group safety climate in construction: The development and evaluation of a typology. *Construction management and economics*, *28*(10), 1099-1112.

Lu, C. S., and Yang, C. S. (2010). Safety leadership and safety behavior in container terminal operations. *Safety science*, *48*(2), 123-134.

Luria, G. (2010). The social aspects of safety management: Trust and safety climate. *Accident analysis & prevention*, *42*(4), 1288-1295.

Luria, G., and Morag, I. (2012). Safety management by walking around (SMBWA): A safety intervention program based on both peer and manager participation. *Accident analysis and prevention*, *45*, 248-257.

Mearns, K., Whitaker, S. M., & Flin, R. (2003). Safety climate, safety management practice and safety performance in offshore environments. *Safety science*, *41*(8), 641-680.

Meliá, J. L., Mearns, K., Silva, S. A., and Lima, M. L. (2008). Safety climate responses and the perceived risk of accidents in the construction industry. *Safety science*, *46*(6), 949-958.

Milijic, N., Mihajlovic, I., Strbac, N., and Zivkovic, Z. (2013). Developing a questionnaire for measuring safety climate in the workplace in Serbia. *International journal of occupational safety and ergonomics*, *19*(4), 631-645.

Mosher, G. A. (2011). *Measurement and analysis of the relationship between employee perceptions and safety and quality decision-making in the country grain elevator*.(Doctoral dissertation, Iowa State University).

Mosher, G. A., Keren, N., Freeman, S. A., and Hurburgh Jr, C. R. (2013). Measurement of worker perceptions of trust and safety climate in managers and supervisors at commercial grain elevators. *Journal of agricultural safety and health*, *19*(2), 125.

Nahrgang, J.D., Morgeson, F.P., Hofmann, D.A., 2008. Predicting safety performance: a meta-analysis of safety and organizational constructs. In: Presented at the Annual Meeting of the Society for Industrial and Organizational Psychology, San Francisco, April.

Neal, A., & Griffin, M. A. (2004). Safety climate and safety at work. *The psychology of workplace safety*, 15-34.

Nielsen, M. B., Mearns, K., Matthiesen, S. B., & Eid, J. (2011). Using the Job Demands–Resources model to investigate risk perception, safety climate and job satisfaction in safety critical organizations. *Scandinavian journal of psychology*, *52*(5), 465-475.

O'Connor, P., O'Dea, A., Kennedy, Q., and Buttrey, S. E. (2011). Measuring safety climate in aviation: A review and recommendations for the future. *Safety science*, *49*(2), 128-138.

Payne, S. C., Bergman, M. E., Beus, J. M., Rodríguez, J. M., and Henning, J. B. (2009). Safety climate: Leading or lagging indicator of safety outcomes?. *Journal of loss prevention in the process industries*, *22*(6), 735-739.

Pousette, A., Larsson, S., and Törner, M. (2008). Safety climate cross-validation, strength and prediction of safety behaviour. *Safety science*, *46*(3), 398-404.

Probst, T. M. (2004). Safety and insecurity: exploring the moderating effect of organizational safety climate. *Journal of occupational health psychology*, *9*(1), 3.

Robinson, S. L. (1996). Trust and breach of the psychological contract. *Administrative science quarterly*, 574-599.

Sampson, J. M., DeArmond, S., and Chen, P. Y. (2014). Role of safety stressors and social support on safety performance. *Safety science*, *64*, 137-145.

Simpson, S. A. (2015). *A study of safety climate and employees' trust of their organizational leadership in university research laboratories* (Doctoral dissertation, Iowa State University).

Singer, S., Lin, S., Falwell, A., Gaba, D., and Baker, L. (2009). Relationship of safety climate and safety performance in hospitals. *Health services research*, *44*(2p1), 399-421.

Shen, Y., Tuuli, M. M., Xia, B., Koh, T. Y., and Rowlinson, S. (2015). Toward a model for forming psychological safety climate in construction project management. *International journal of project management*, *33*(1), 223-235.

Siu, O. L., Phillips, D. R., & Leung, T. W. (2004). Safety climate and safety performance among construction workers in Hong Kong: The role of psychological strains as mediators. *Accident analysis & prevention*, *36*(3), 359-366.

Skogdalen, J. E., Utne, I. B., and Vinnem, J. E. (2011). Developing safety indicators for preventing offshore oil and gas deepwater drilling blowouts. *Safety science*, *49*(8), 1187-1199.

Smith, G. S., Huang, Y. H., Ho, M., and Chen, P. Y. (2006). The relationship between safety climate and injury rates across industries: The need to adjust for injury hazards. *Accident analysis and prevention*, *38*(3), 556-562.

Stetzer, A., and Hofmann, D. A. (1996). Risk compensation: Implications for safety interventions. *Organizational behavior and human decision processes*, *66*(1), 73-88.

Tholén, S. L., Pousette, A., and Törner, M. (2013). Causal relations between psychosocial conditions, safety climate and safety behaviour–A multi-level investigation. *Safety science*, *55*, 62-69.

Vinodkumar, M. N., and Bhasi, M. (2009). Safety climate factors and its relationship with accidents and personal attributes in the chemical industry. *Safety science*, *47*(5), 659-667.

Wu, T. C., Chen, C. H., and Li, C. C. (2008). A correlation among safety leadership, safety climate and safety performance. *Journal of loss prevention in the process industries*, *21*(3), 307-318.

Zhou, Q., Fang, D., and Wang, X. (2008). A method to identify strategies for the improvement of human safety behavior by considering safety climate and personal experience. *Safety science*, *46*(10), 1406-1419.

Zohar, D. (1980). Safety climate in industrial organizations: theoretical and applied implications. *Journal of applied psychology*, *65*(1), 96.

Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. *Accident analysis and prevention*, 42(5), 1517-1522.

Zohar, D., and Luria, G. (2005). A multilevel model of safety climate: cross-level relationships between organization and group-level climates. *Journal of applied psychology*, 90(4), 616.

Zou, P. X., and Sunindijo, R. Y. (2013). Skills for managing safety risk, implementing safety task, and developing positive safety climate in construction project. *Automation in construction*, *34*, 92-100.

CHAPTER 5. CONSIDERING USE OF THE INFORMED CONSTRUCTIVIST GROUNDED THEORY IN RESEARCHING SAFETY CLIMATE

A manuscript to be submitted to *Safety and Health at Work*

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Abstract

Grounded Theory is a research methodology which has been used in the social sciences since the 1960s. Allowing researchers the freedom to investigate a research topic or problem without formulating a hypothesis to test against, Grounded Theory also allows researchers the ability to collect data through multiple streams and at multiple points through the study until the researcher feels that enough information has been gathered to properly answer the research questions. The study discussed in this paper uses the basics of Grounded Theory to investigate perceptions of safety climate, combining data streams from quantitative analysis of survey data as well as qualitative analysis of narrative collection data. The combined data are used to put forth a new definition of safety climate as it pertains to the populations sampled in this study.

Introduction

Safety climate in the workplace has received much research attention over the years (Cooper and Phillips, 2004; Neal and Griffin, 2000; Guldenmund, 2000; Zohar, 1980, 2000, 2002a, b; Zohar and Luria, 2003, 2004), and have expanded upon the original work by Zohar (1980). Zohar (1980) initially studied 20 Israeli factories across a variety of industries and defined safety climate as "*a summary of molar perceptions that employees share about their work environment"* (pg 96). Safety climate can also be 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.*, 2006). It can also be described as a multidimensional construct believed to influence the safety behavior of workers at the individual, group, or organizational level (Smith *et al.*, 2006). Yet, safety climate is only one variable that contributes to safe behavior and influences accident and injury rates. (Beus *et al.*, 2010). Additionally, recent meta-analyses (Beus *et al*., 2010; Christian *et al.,* 2009; Kuenzi and Schminke, 2009) suggest a positive relation between safety climate and safety outcomes, which is to say that a positive safety climate correlates with positive safety performance (lack of incidents/injuries in the workplace).

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, 2007) and negative associations with workplace accidents and injuries (Hofmann and Stetzer, 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.

The majority of safety climate research follows the framework proposed by Zohar (1980) which utilizes a multi-item survey instrument whose data are examined through some form of structural equation modeling such as exploratory factor analysis which seeks to uncover latent factors which reveal shared perceptions of the organization's safety climate, or state another way, exploratory factor analysis allows researchers to investigate concepts that are not easily measured directly by collapsing a large number of variables into a few interpretable underlying factors. This original study found factors of:

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
8. Effect of safe conduct on social status

These factors were clustered into five core constructs of safety climate: management commitment to safety, supervisory safety support, coworker (safety) support, employee (safety) participation, and competence level (Zohar, 1980). Numerous studies carried out since 1980 (see Nahrgang, Morgeson, and Hofmann, 2007; Christian *et al*., 2009 for meta-analyses) utilized an instrument similar to or derived from the original Zohar instrument.

While not explicitly stated as such, these previous studies are often associated with a Positivist epistemology. These studies, in their quest for objective knowledge through theory testing and deductive reasoning, seek to explain how and why things happen through approaches such as measurement, statistical logic, and correlation. Through the administration of a survey instrument and subsequent data analysis, a researcher is able to determine through a combination of statistical results and theory, which survey questions adequately group together and what that grouping is based upon, allowing for the naming of factors. These results are often combined with a reliability analysis and the presentation of Cronbach's alpha values demonstrating how well the items under a particular factor group together and measure what they are purported to measure. Through these statistical and reliability analyses, the results of these types of studies can be written up and discussed in terms of "the following factors influence safety climate perceptions". This process is graphically represented in Figure 1. The research discussed in this paper seeks to ask another level of question, namely "now that potential factors influencing safety climate have been identified, to what degree do those factors influence and can be assessed through an additional data collection?"

Figure 1. Diagram of basic Positivist research process

The Positivist epistemology allows for research which is rigorous and can be replicated. Through the write up of results and recommendations for future research, researchers are able to use results of previous studies to aid in the formulation of new research questions. Researchers educated in natural science fields which rely nearly exclusively on quantitative analyses of data are familiar and comfortable with the Positivist perspective. This concept contrasts with the Interpretivist epistemology, found in social science disciplines and often termed a "qualitative" view.

Fewer research studies performed over the last nearly 40 years have been conceptualized or carried out in a purely qualitative manner. Published research in health care, nursing, and mental health care has used a qualitative approach (Flin, 2007; Zuniga, *et al*., 2013). Other studies have focused on psycho-social/socio-technical issues such as organizational leadership (Chughtai, 2015; Clarke, 2013; Hoffmeister *et al*., 2014; O'Dea and Flin, 2001; Wu, Chen, and Li, 2008), management systems (Hale *et al*, 2010; Makin and Winder, 2008; Whitener *et al.*, 1998) and have approached measurement of these issues using quantitative methodology, furthering the positivist approach to investigating safety climate. If it is assumed that a workplace and its workers, supervisors, and management can be thought of as a social structure, then it seems reasonable that using qualitative measures would aid a researcher in more thoroughly investigating the topic of safety climate. By using both quantitative and qualitative methods of data collection and analysis, the researcher has the potential for a more diverse and richer pool of data and results from which to postulate results regarding not only what factors influence safety climate perceptions, but also to what degree they influence those perceptions.

Many published quantitative studies conclude the potential existence of psycho-social and socio-technical factors (Avci and Yayli, 2014; Cooper and Phillips, 2004; Tholén, Pousette, and Törner, 2013; Sampson, DeArmond, and Chen, 2014; Zúñiga *et al.,* 2013). Generally, these are discussed in terms of avenues for future research and if follow-up studies are performed, these issues are examined using quantitative instruments. Safety climate has been historically been measured quantitatively using Likert-scaled surveys analyzed through some statistical method, and the results of which can be compared to other occupational data such as accident reports, hazard analysis, environmental monitoring, engineering controls, worker's compensation, and a myriad of other topics which produce data that can be counted, sorted, and analyzed for patterns. However, the human nature of workers – thoughts, feelings, perceptions, and motivations – are topics which are challenging to adequately quantify and which lend themselves to qualitative measures such as interviews, narrative collection, and ethnographies. Seen from a review of relevant literature, research into the topic of safety climate is an *either/or* proposition. *Either* investigated quantitatively or investigated qualitatively. *Either* approaching research questions from a Positivist perspective or approaching them from an Interpretivist perspective. Little published research has approached the problem from an epistemology that bridged the gap between Positivism and Interpretivism. Further, using both quantitative and qualitative methods of data collection allowing researchers to address different types of research questions. Figure 2 shows the process of the proposed mixed-methods approach using Grounded Theory as the bridge between the currently favored methods.

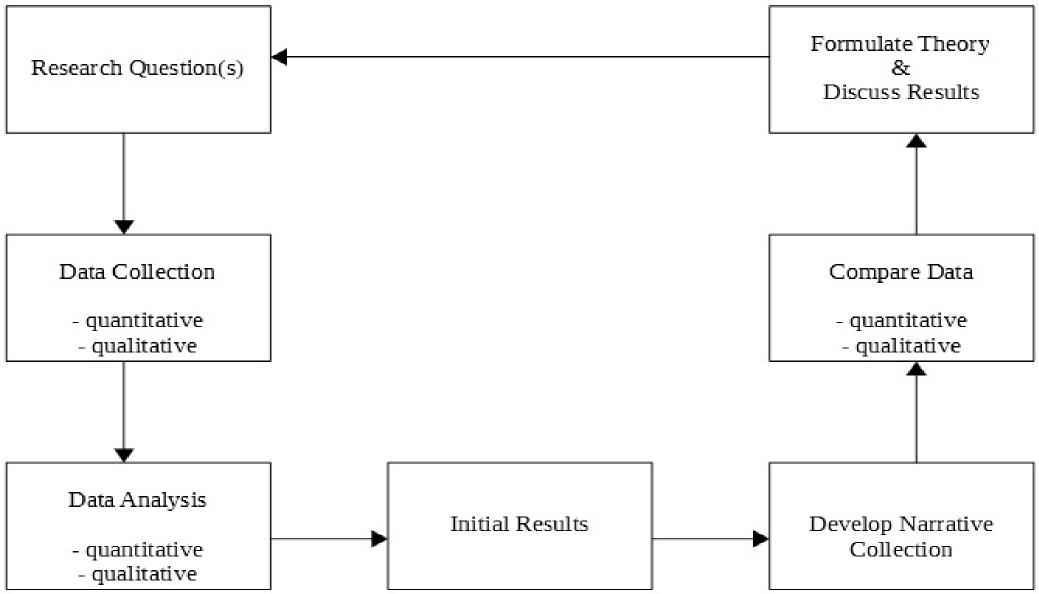

Figure 2. Diagram of basic mixed-methods using Grounded Theory

Grounded Theory

Grounded theory was developed and introduced to the research community by Glaser and Strauss (1967), where the authors postulated that neither quantitative nor qualitative research methods were successful in closing the gap between theory and empirical research (Babchuk 2009). The research climate of the 1960s was largely deductive and focused on testing rather than developing theory (Glaser and Strauss, 1967), where researchers examined hypotheses by measuring variables, providing them with powers of prediction and control (Glaser 1978). Due to the favoritism towards quantitative research, the 1960s were characterized by a prominent distaste towards 'impressionistic, anecdotal, unsystematic, and biased' qualitative research (Charmaz 2006).

Glaser and Strauss (1967) also noted an overemphasis on the verification of theory and a lack of emphasis on discovering concepts grounded in the data of the research.

Arguing that part of the utility of theory in sociology were that theory be usable in practical applications and give practitioners both understanding and some control, Glaser and Strauss (1967) proposed that this understanding and control could be better accomplished through "systematic discovery of the theory from the data of social research" (pg 3) (Glaser and Strauss, 1967). Rejecting the traditional positivist-oriented quantitative methodologies that had dominated social science research, Glaser and Strauss offered a new approach to inquiry – grounded theory – based on rigorous and systematic qualitative procedures which seek to develop a theory based on the data, rather than the non/verification of a pre-existing hypothesis (Babchuk, 2009). Inductive methods were applied in grounded theory, which enabled development of theory through iterative and systematic processes involving manual coding, categorizing and comparing data, without guidance of a preconceived theory (Glaser and Strauss, 1967). This approach agreed with positivist epistemological view, as it was systematic, rigorous, and could be replicated (Charmaz 2006, 2008, Bryant and Charmaz, 2007), and also incorporated the symbolic interactionism view of qualitative research, which calls for 'human reflection, choice, and action' (Charmaz, 2008).

Grounded Theory was groundbreaking when developed because it defied a long-standing belief that qualitative research was disorganized and unmethodical. For the first time, it combined data collection and data analysis into one collective task and encouraged theory development (Charmaz, 2008). Grounded Theory's original methodology was characterized by an ongoing and systematic process of collecting, coding, analyzing and theoretically categorizing data using information that emerges from the data itself, rather than forcing preconceived ideas onto the coding and subsequent analysis (Lauridsen and Higginbottom, 2014). The central principle of data analysis in Grounded Theory research is constant comparison – as issues of interest are noted in the data, they are compared with other examples for similarities and differences (Lingard, Albert, and Levinson, 2008). After initial data is coded and categorized, additional data are sought through further sampling and compared to emergent categories until data saturation occurs. Saturation referring to ensuring that adequate and quality data are collected to support the study. This method of "constant comparison" allows for the development of a theory which is analytically *grounded* in the data (Hood, 2007). Through the process of constant comparison, emerging theoretical constructs are continuously refined through comparison with fresh examples from ongoing data collection, which produces the 'richness' attributed to grounded theory analysis (Lingard, Albert, and Levinson, 2008). Popular not only in sociology, but across many other disciplines such as health care, nursing, information systems, management, psychology, anthropology, social work, and education, grounded theory has gained momentum as a qualitative design (Babchuk, 2008; Goulding, 2002). According to Babchuk (1997), grounded theory's emphasis on simultaneous and ongoing data analysis, theoretical sampling procedures, and the generation of theory from data collected in the field, seems ideally suited for furthering the link between research and practice.

Whereas most methodologies develop a theory prior to data collection and the results of the data are used to confirm or fail to confirm the theory, Grounded Theory seeks to develop its theory *after* the data has been collected and analyzed and the theory serves as a succinct possible explanation of the results of the data which can be further examined, refined, or revised as more studies are performed and more data is collected. Where quantitative studies will develop or deploy a research instrument to gather data and the results from the instrument are the only results the researcher has to analyze, Grounded

Theory utilizes *constant sampling* which allows the researcher to deploy an instrument, analyze the results, then sample further if something interesting emerges from the initial sampling. This process is continued until the researcher feels that they have *saturation* of data from which to draw some conclusions. Informed Constructivist Grounded Theory expands upon this approach by combining the results of the data collected during the study with a thorough review of the literature related to the research topic.

Constructivist Grounded Theory

Constructivist Grounded Theory (CGT) was first introduced in 1994 by Charmaz. Situated epistemologically between positivism and post modernism, it (CGT) asserted that researchers are a part of the world that is studied and the data that is collected (Charmaz, 1995). In this initial as well as subsequent writings, Charmaz (1995) proposed an approach to GT which was 'a contemporary revision of Glaser and Strauss' classic grounded theory' (Charmaz, 2009). Charmaz (2006) defined constructivism as "a social scientific perspective that addresses how realities are made. This perspective assumes that people construct the realities in which they participate" (Lauridsen and Higginbottom, 2014). Therefore, as researchers, theories are constructed through past and present interactions with people, perspectives and research practices (Gardner, McCutcheon, and Fedoruk, 2012). Specifically, Charmaz developed an argument against positivist assumptions that 1) one external reality exists, 2) research should be generalizable, and 3) the researcher is an objective observer with little influence on the data and the analytic processes (Wertz *et al*., 2011; Lauridsen and Higginbottom, 2014).

Charmaz (2006) proposed a Grounded Theory (GT) methodology founded on a relativist epistemology, which suggests that the theories researchers construct through the methods proposed by Glaser and Strauss are affected by the researchers' interactions with people, places, education, and opinions. Charmaz (2006) further argued that researchers cannot separate themselves and their experiences from their research or be truly objective about the data, but instead make consistent and ongoing subjective interpretations of the data. The researchers' ideas are thought to be grounded in their perspectives, privileges, positions, interactions and geographical locations (Charmaz, 2009). Ultimately, the findings of a researcher are not representative of a singular reality but are interpretations of multiple realities 'mutually constructed by the researcher and the participants being researched' (Lauridsen and Higginbottom, 2014 c. Wertz *et al*., 2011). Constructivist Grounded Theory attempts to develop detailed understanding of underlying social or psychological processes within a certain context by exploring social interactions and social structures in more detail (Charmaz, 2006). Using a CGT approach allows the researcher to focus attention on the underlying social process that might be occurring in any given context. While not immediately apparent, this underlying social process might emerge over time as the data is analyzed and theorizing begins (Charmaz, 2006). Charmaz (2006) suggested that the final theory generated in CGT is a co-construction – the researcher's construction of the participants' constructions (Lauridsen and Higginbottom, 2014). Researchers approach their research questions with disciplinary interests, background assumptions and a familiarity with the literature in the domain, but hypotheses are neither developed nor tested using grounded theory, and the theory that "explains" the information and themes in the data emerges through a detailed analysis of the data (Lingard, Albert, and Levinson, 2008). According to

Lauridsen and Higginbottom (2014), GT has the potential of a solid methodology through its flexibility of approaches that a variety of researchers can match to their own perspectives and research needs.

Methods

The investigation of safety climate using the methodology of an informed constructivist grounded theory (ICGT) was borne from a review of the literature associated with safety climate. Specifically, the work by Zohar (2010) were considered. In the article (Zohar, 2010), Zohar reflected on 30 years of safety climate research and the need to expand upon what has already been accomplished and to look at safety climate in new way and to consider new methods. The questions presented here represent the thought process of the researcher working towards the formulation of research questions. While many of these questions challenge the established research methodology in safety climate research, the questions can be represented as the intersection of the three spheres of Ontology, Epistemology, and Methodology as shown in figure 3.

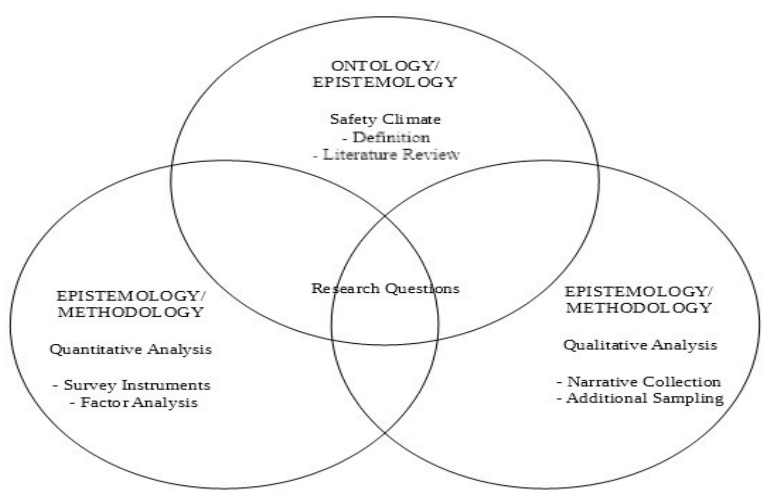

Figure 3. Venn diagram of Ontology, Epistemology, Methodology in this study

How is safety climate measured? Asked from both an epistemological and methodological perspective, this question seeks to answer – how can the phenomena be investigated or studied, and which methods are suitable for our investigation(s)? A review of literature produced numerous studies where safety climate was *measured* using a survey instrument of a specific number of questions. The results of those surveys were examined using statistical methods, most commonly through some aspect of structural equation modeling like factor analysis, in an effort to determine if there were a smaller number of factors which adequately explain the variables (Schneider *et al.*, 2000; House, Rousseau, and Thomas-Hunt, 1995; Klein, Dansereau, and Hall, 1994; Kozlowski and Klein, 2000; O'Reilly, 1991; Reichers and Schneider, 1990; Zohar, 1980, 2000, 2003). Additionally, while there are research studies that suggest safety climate scores are correlated with safety performance (O'Dea and Flin, 2001; Neal and Griffin, 2000, 2006; Zohar, 1980; Zohar and Luria, 2005), is too much value placed on the correlation and suggesting in a veiled manner that correlation is equal to causation? If researchers assess safety climate scores using a survey instrument and after analysis an *average* safety climate score for the population is calculated, what does that number mean, exactly? For example, if a population has a score of 2.39 out of 5.00, what does that 2.39 measure? Is 2.39 better than, say, 2.29? If so, why and by how much exactly? Are too many assumptions being made regarding scales? Have researchers become complacent with the use of the Likert-scales to *measure* safety climate?

When performing a factor analysis of survey data and analyzing the results to determine which *factors* the survey questions load on, the researcher must be involved in making the determination at what loading level to use as the cut-off (0.30 refers to a medium effect level), and once the survey questions load acceptably on only one principle factor, the researcher must then assign a label or name the factors. The naming of these factors that have emerged from the analysis is based on 1) previous research studies – are these factors similar to others that other studies have uncovered? 2) theory – do the questions associated with a factor have some commonality to make assigning a useful label to them possible? and 3) judgment of the researcher – while the output of the factor analysis indicates which survey questions group together under each particular factor, it is ultimately up to the judgment of the researcher to assign a label to those factors to use in the discussion of them in the results section of a research paper. With this aspect of factor analysis in mind, is there not a component of *making meaning* inherent to this approach? Are researchers not constructing understanding and knowledge through this theoretical and judgment-based final step in factor analysis?

What is being measured? If researchers accept the commonly used definition of safety climate as "*a summary of molar perceptions that employees share about their work environment"* (Zohar, 1980, pg 96), then what is being measured? Can, or should researchers, measure the way someone *thinks* about something with a quantitative instrument, and if such an instrument is used, what do the results represent? Fundamentally it is accepted that the collected data are merely a snapshot of the time period in which the data were taken. While researchers can test-retest to ensure validity, each survey administered is but a snapshot. Perception, being related to learning and understanding, is a fluid concept that is influenced by a variety of factors, not the least of which is the emotional state of the respondent at the time of the survey. Can it be said with confidence that these survey instruments are accurately gauging the *shared perceptions* of the workforce in terms of safety climate in their facility? Are researchers assuming that between any two respondents that their individual perceptions of what constitutes *positive(good)* or *negative(bad/poor)* safety climate are the same? Are researchers assuming that among the sample population the differences in perceptions will average out through the calculations and that the *average safety climate score* is a number that has some sort of meaning in terms of how a research sample population *perceives* safety climate in their facility or workplace?

Are the data sufficient? Using the results from the statistical analyses performed during the course of this research study, the factors identified through exploratory factor analysis were *Supervisor Involvement, Management Commitment to Safety* for the agricultural bulk commodity storage/handling facility and *Supervisor Communication Reliability, Positive Safety Actions, Supervisor Dependability,* and *Supervisor Consistency* for the university research laboratories. For each data set, the results of the analysis showed particular survey questions adequately loading on a particular factor. Once those questions were reviewed to determine what they might have in common through their wording or what they intended to measure, the factor was assigned a name that seemed to *make sense* in a contextual manner. If measuring individual and group perceptions, then is the naming of a factor and presenting the results of the statistical analysis sufficient? Depending on the research questions put forth at the beginning of the study, analysis and presentation of results may be sufficient to answer those questions.

In addition to the multi-item survey which was analyzed using factor analysis, both the data sets used for this research also utilized a 6-item questionnaire which collected demographic information such as *gender, age range, education level, tenure at workplace, tenure with current supervisor* and *frequency of safety training.* The agricultural bulk commodity storage/handling facility's questionnaire had two additional questions asking for self-report ratings of *job satisfaction* and *fair pay*. This small questionnaire, also Likert-scaled, produced data categorical in nature, and as such, Analysis of Variance (ANOVA) was used to determine if any of the variables (questions) were statistically significant predictors of safety climate scores. For the agricultural bulk commodity storage/handling facility, both *job satisfaction* and *fair pay* were found to be statistically significant ($p<0.05$), while the university research laboratory questionnaire did not reveal any statistically significant variables. When combined with the results from the exploratory factor analyses, these data provided a total of eight potentially influential factors that might influence the perception of safety climate in these two facilities.

What else can be done? This question asks in a rhetorical manner "*Now that the exploratory factor analysis on the survey has been completed, the ANOVA on the questionnaire has been completed, with valid results – what more about safety climate is known now than before the analyses?*" Early in the conceptualization stage of this research project, the researcher pushed towards performing a mixed-methods study using both quantitative data and qualitative measures in order to answer the research questions. Mixed methods were decided upon for a number of reasons: 1) limited mixed methods research has been published in the field of occupational safety and health, 2) to more thoroughly assess constructs of *thoughts, feelings* and *perceptions*, the additional data collection from a qualitative component may reveal new and interesting information, and 3) performing a mixed methods study in a field that has not used this method and investigating a research topic that has been thoroughly investigated by quantitative studies in the last 40 years is a departure from conventional safety climate research.

Research Questions

The following research questions drove this research:

1. What gaps in knowledge regarding safety climate perceptions in agricultural bulk commodity storage/handling facilities can be addressed through application of an informed constructivist grounded theory approach to investigation and its additional data collection?
2. What gaps in knowledge regarding safety climate perceptions in university research laboratories can be addressed through application of an informed constructivist grounded theory approach to investigation and its additional data collection?
3. Through additional data collection in these two industries, can a new theory regarding the factors that influence safety climate perceptions be developed, and can this new theory refine our approach to investigating this topic in the future?

Initial Results

Two sets of data were used in this research study. One came from a large agricultural bulk commodity storage/handling company (Mosher, 2011), the other from research laboratories from a large university (Simpson, 2015). These seemingly dissimilar data sets were used because both agriculture and university laboratory research are occupational sectors that have historically been under-represented in the literature in terms of safety science research. For each of the data sets, a multi-item survey instrument was used to assess safety climate, and each set used a derivative of the 40-item Zohar Safety Climate Questionnaire developed by Zohar and Luria (2005). In addition to the safety climate survey instrument, both the agriculture and laboratory data included a short questionnaire which gathered demographic data (gender, age group, education level, tenure in position, tenure under supervisor, frequency of safety training), with the agriculture data collecting two additional pieces of data – self-reported values of “job satisfaction” and “fair pay”. Safety climate survey data were analyzed using exploratory factor analysis with an additional reliability analysis. The short questionnaire data was analyzed using Analysis of Variance (ANOVA). Across both data sets and both methods of statistical analysis, a total of 8 factors/variables were identified as being statistically significant in explaining safety climate perceptions.

The factors and statistically significant variables were used as the basis of questions for narrative inquiry as the qualitative portion of the research study. Although it is commonly assumed that Grounded Theory is the best suited for developing theories about psychological and social processes, narrative inquiry has also been used to theorize psycho-social processes (Lal, Suto, and Ungar, 2012). Narrative inquiry first appeared in the work of researchers from the Chicago School of Sociology in the early part of the 20th century, where realist ontological perspective dominated, and sociologists and anthropologists were interested in the “what” of the stories told (Chase, 2005). Charmaz (2009) suggested the task of the researcher is to learn the methods by which participants construct their respective realities, and to make further interpretations about this reality by framing a participant’s personal meaning and action in large social structures which they may be unaware of (Lauridsen and Higginbottom, 2014). Qualitative researchers are commonly interested in individual experiences and processes related to a particular phenomenon, as well as those experiences and processes common across a group of participants – this dual concern can be addressed by combining methodological approaches which harness the strengths of both Grounded Theory and narrative inquiry (Lal, Suto, and Ungar, 2012). The following questions were developed from the quantitative factors and statistically significant variables identified, and the results of the analysis of collected data are discussed below. These questions were distributed via online survey instrument to employees from the two industrial sectors discussed earlier, and with the number of respondents who elected to complete the survey, a total of 108 data points (12 respondents x 9 questions per respondent) were examined for their content. Results of the narrative collection portion of data collection revealed that across the 108 data points, 93.5% of those data points indicate that a particular factor/variable has an impact on a respondent's personal perception or overall perception of safety climate in the workplace.

Question #1 to frame all responses – *How would you personally define the term "safety climate"?* 10 respondents had at least an intuitive sense of what is meant by "safety climate". Of the 2 remaining respondents one respondent failed to answer the question entirely while the other respondent typed "*poorly*" for their answer.

Factor 1 – Supervisor Involvement – Please describe in what way you feel your supervisor is involved in fostering a positive safety climate in your facility. All of the respondents had their own ideas of how supervisors *should be* involved in fostering a positive safety climate, or they had first-hand experience in their workplace with a supervisor *who was/is* involved in fostering a positive safety climate.

Factor 2 – Management Commitment – Please describe in what way you feel upper level or senior management in your facility is committed to fostering a positive safety climate. 11 respondents felt the senior-level personnel in their organization were currently committed to fostering a positive safety climate or had suggestions of how senior-level personnel could demonstrate their commitment. One respondent answered "I don't know".

Factor 3 – Supervisor Communication Reliability – Please describe how the reliability of a supervisor's communication influences your perception of safety climate? i.e. a supervisor says the same thing from one time to the next or says the same things to different people or levels of the organization. 11 respondents believed that the reliability/consistency of a supervisor's communication had an impact on safety climate. One respondent did not provide an answer to this question.

Factor 4 – Positive Safety Actions – Please describe in what way positive safety actions taken by employees or supervisors have an effect on the overall safety climate of the organization. All respondents either had ideas of what kinds of actions could be taken at work to foster a positive safety climate or were able to recount examples from their own life demonstrating how positive safety actions had helped to foster a positive safety climate in the workplace.

Factor 5 – Supervisor Dependability – Please describe in what way the dependability of a supervisor (either through things they say or things they do) influence the overall safety climate of the organization. 11 respondents provided examples from their own life demonstrating how the dependability of a supervisor helped to foster a positive safety climate or had ideas how a supervisor being considered dependable could help improve safety climate. One provided no answer this question.

Factor 6 – Supervisor Personal Stability – Please describe in what way the stability of a supervisor's personality (acts in a consistent and predictable manner, responds appropriately to situations) influence the overall safety climate of the organization. 11 respondents provided examples demonstrating/explaining how a supervisor's personality can or does affect the safety climate of a workplace. One answered "choose not to comment".

ANOVA variable 1 – Job Satisfaction – Do you believe that your personal level of job satisfaction has an impact on the safety climate of the facility you work in? All respondents felt that their own level of satisfaction with the job has a definite impact on the safety climate of the workplace. In 50% of the responses, the respondents either explicitly stated or implied that if multiple people in a facility were unsatisfied at work that safety climate could be negatively impacted in a cumulative manner.

ANOVA variable 2 – Fair Pay – Do you believe that your personal feeling regarding how fairly you are paid for your work has an impact on the safety climate of the facility you work in? 11 respondents felt that being paid fairly had an impact on safety climate in the workplace. Of particular note in the narratives, the respondents spoke of being paid fairly in parallel with job satisfaction, and that if a person was not paid fairly for their work that they would be seeking employment elsewhere. One respondent answered "N/A, I am an unpaid intern".

Carried out in a semi-structured format, where no specific hypothesis was set nor tested prior to beginning the analysis of existing data and collection of new data, the anticipation was that the information gathered in the narrative collection would reinforce the quantitative analysis.

The results of the narrative collection agree with the quantitative results – that is, not only do the statistics indicate a factor or variable has an impact on safety climate perceptions in the industries examined in this research, but the information gathered from employees in these industries agrees with this. Additionally, through the additional data collection opportunity afforded to the researcher by use of the Constructivist Grounded Theory approach to methodology, not only is it possible to make claims about which factors or variables are significant predictors of safety climate perceptions in the workplace, but it is also possible to get a sense of to what degree these factors or variables impact. In this vein, research questions 1 and 2 of this study:

1. What gaps in knowledge regarding safety climate perceptions in agricultural bulk commodity storage/handling facilities can be addressed through application of an informed constructivist grounded theory approach to investigation and its additional data collection?

2. What gaps in knowledge regarding safety climate perceptions in university research laboratories can be addressed through application of an informed constructivist grounded theory approach to investigation and its additional data collection? - can be answered broadly by saying that the addition of a qualitative portion of data collection to examine safety climate perceptions failed to uncover gaps in the quantitative assessment. However adding the qualitative assessment helped to verify the results of the quantitative assessment and the survey instrument used to carry out that portion of data collection.

The third research question:

3. Through additional data collection in these two industries, can a new theory regarding the factors that influence safety climate perceptions be developed, and can this new theory refine our approach to investigating this topic in the future? - can be answered in the affirmative. Through the administration of a survey instrument to gather information from a target population regarding their perceptions of safety climate → using statistical methods to examine that data and uncover a number of latent factors which adequately "explain" safety climate perceptions → using the results of the statistical analysis to drive the development of a set of questions to administer to the target population in the form of narrative collection → gathering the narrative information and examining it for common themes and whether it confirms the results of the quantitative analysis or refutes them → the researcher believes that enough information has been gathered and examined to formulate a theory of safety climate perceptions. Limited in potential broader applicability, and perhaps only appropriate to the industry segments examined in this study and to the populations sampled, the succinct theory is presented below along with discussion where the theory is deconstructed into parts and examined for which data corresponds to or grounds each portion.

"Safety Climate is constructed of individual and group perceptions of the overall health of the safety programs in the workplace, the relationships with and among the levels of the organizational hierarchy as they pertain to safety, as well as personal perceptions of reciprocity in terms of job satisfaction and fair pay as they pertain to employees and their employer."

Previous research studies (Griffin and Neal, 2000; Kath, Magley, and Marmet 2010; Mosher *et al.*, 2013; Mueller *et al.*, 1999; Shannon and Norman, 2009; Zohar, 2000; Zohar and Luria, 2003; Zohar and Luria, 2005) have examined safety climate for both group (management) and individual (employee) levels. Data collected as part of this study found group and individual constructs to be present in both the agricultural bulk commodity handling/storage facility and university research laboratory's safety climate survey data. Specifically, the agricultural bulk commodity data revealed the factors of *Management Commitment* and *Supervisor Involvement*, while the university research laboratory data revealed factors of *Supervisor Communication Reliability, Supervisor Dependability,* and *Supervisor Consistency.* Moreover, the responses gathered through narrative collection seem to indicate that employees believe the words, deeds, and personalities of people in the organization have a direct impact on the overall safety climate of the workplace. Specifically, the narratives collection questions corresponding to the factors of *Management Commitment, Supervisor Involvement*, *Supervisor Communication Reliability, Supervisor Dependability,* and *Supervisor Consistency* were answered by the respondents in such manner to indicate either a personal feeling or thought of how this factor might/does influence safety climate, or through recollection of a past experience to illustrate the influence of a particular factor. With these group and individual constructs identified through both quantitative and qualitative inquiry, this new theory of safety climate contains the phrases "*Safety Climate is constructed of individual and group perceptions...*" as well as "*...relationships with and among the levels of the organizational hierarchy...*".

Wu, Chen, and Li (2008) identified safety climate 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. Additionally, safety climate measures perceptions of the CEOs' and managers' safety commitment and action by employees, which influence the safety organization and management, safety equipment and measures, and accident investigations (Wu, Chen, and Li, 2008). Research literature also indicates that safety climate predicts employees' motivation to work safely, which affects employees' safety behaviors and subsequent experiences of workplace injuries or incidents (Griffin and Neal, 2000; Mueller *et al*., 1999; Zohar and Luria, 2003). Results from the factor analysis revealed a latent factor of *Positive Safety Actions* as influencing overall safety climate perceptions, and results from the narrative inquiry corroborate this with numerous responses from the participants providing examples of how performing a positive action at work with regards to safety, seeing someone else at work behaving safely, or supervisors/managers being positively engaged in safety at work are influential to the participant's perception of safety climate. These results correspond to the phrase in the new theory of safety climate "*... the overall health of the safety programs in the workplace...*".

There does not appear to be any clear link between pay, wages, or compensation and its effects on safety climate in the literature. Identified as a statistically significant predictor of safety climate perceptions through ANOVA of the supplemental questionnaire distributed in the Mosher (2011) study, this variable/factor was spoken of in the results from the narrative collection as being influential to safety climate. However, the responses to this narrative question also appear to speak of fair pay in similar terms to the responses to the question asking about job satisfaction. Previous studies have identified a relationship between job satisfaction and safety climate (Flin *et al.,* 2000; Mearns, Whitaker and Flin, 2003; Neal and Griffin, 2004; Nielsen *et al.*, 2011; Siu, Phillips and Leung, 2004). The collected responses to this narrative question appear to align with these previous studies' findings, and the combination of statistical significance for the variables *Job Satisfaction* and *Fair Pay* with the results of the narrative collection lead to stating in the new theory "*...personal perceptions of reciprocity in terms of job satisfaction and fair pay as they pertain to employees and their employer.*"

While the presented theory has more detail than the definition put forth in 1980 "A summary of molar perceptions employees share about their work environment" (Zohar, 1980, pg 96), Zohar used the term "molar" to refer to large units of behavior, and as his 1980 study examined 20 facilities in a variety of industries in Israel, his sampling size was vastly larger than the study discussed in this paper, thus he was able to speak in larger terms and units. However, the theory presented encompasses not only those factors identified through quantitative analyses to be explanatory of safety climate perceptions, but also includes the corroboration of the narrative inquiry whose results corroborate with the quantitative results.

Further examination through future research studies is required if the presented theory is to be further refined. Through larger scale studies, across a broader scope of industry segments, with a much larger number of respondents for both the quantitative and qualitative portions of data collection, we may in the future be able to say with confidence *what* safety climate is, *what* influences safety climate perceptions, and *to what extent* the identified factors influence safety climate. With this increased understanding, perhaps workplaces wishing to assess safety climate in their facilities could have clearer ideas about what is influencing the climate in their facility, and how to address those things to foster or increase a positive safety climate.

Conclusion

While there have been previous studies in the field of safety climate research that have utilized qualitative methodologies, the bulk of prior studies into this topic have favored quantitative methodologies. Being a topic under a larger natural science construct of "safety", safety climate has been historically considered a topic which lends itself to quantitative research – investigating a myriad of topics which produce data that can be counted, sorted, and analyzed for patterns. The human nature of workers – thoughts, feelings, perceptions, and motivations – are topics which are challenging to adequately quantify and which can lend themselves to qualitative measures. Safety climate is a complex topic, and while Grounded Theory approaches to investigation with its continuous data collection leading to “data saturation” are perhaps not appropriate to every study due to the time and energy needed to carry them out, these approaches can afford the researcher a manner in which to approach the investigation of safety climate when seeking a deeper understanding of the problem.

The use of Grounded Theory to approach the investigation of safety climate is somewhat a novel and unorthodox approach to investigating a topic in occupational safety that has been thoroughly investigated in a variety of industries over the last 40 years. Grounded Theory provides not only a set of tools and justifications for approaching the research without preconceived notions (no hypothesis testing), to continuously collect data in order to increase understanding of the research problem (using two different data collection streams in this research), but also serves as a challenge to the researcher themselves as it encourages new ways to conceptualize a research topic and encourages breaking away from the dichotomous either/o*r* approach to investigating topics through only one epistemological lens.

References

Ajslev, J., Dastjerdi, E. L., Dyreborg, J., Kines, P., Jeschke, K. C., Sundstrup, E., ... and Andersen, L. L. (2017). Safety climate and accidents at work: Cross-sectional study among 15,000 workers of the general working population. *Safety science*, *91*, 320-325.

Avci, C., and Yayli, A. (2014). Examining safety behaviour with the safety climate and the theory of planned behaviour. *International journal of arts and sciences*, *7*(4), 611.

Babchuk, W. A. (1997). The rediscovery of grounded theory: Strategies for qualitative research in adult education.

Babchuk, W. A. (2008, October). Variations on a theme revisited: Operationalizing grounded theory for research and practice. In *Proceedings of the 27th annual midwest research-to-practice conference in adult, continuing, and community education* (pp. 7-13).

Babchuk, W. A. (2009). Grounded theory for practice-based application:"Closing the embarrassing gap between theory and empirical research". *International journal of qualitative methods*, *5*(1), 1-10.

Barbaranelli, C., Petitta, L., and Probst, T. M. (2015). Does safety climate predict safety performance in Italy and the USA? Cross-cultural validation of a theoretical model of safety climate. *Accident analysis and prevention*, *77*, 35-44.

Beus, J. M., Payne, S. C., Bergman, M. E., and Arthur Jr, W. (2010). Safety climate and injuries: an examination of theoretical and empirical relationships.

Bryant, A., and Charmaz, K. (Eds.). (2007). *The Sage handbook of grounded theory*. Sage.

Charmaz, K. (1995). Between positivism and postmodernism: Implications for methods. *Studies in symbolic interaction*, *17*(2), 43-72.

Charmaz, K. (2006). Constructing grounded theory: A practical guide through qualitative research. *Sage Publications Ltd, London*.

Charmaz, K. (2008). The legacy of Anselm Strauss in constructivist grounded theory. In *Studies in symbolic interaction* (pp. 127-141). *Emerald Group Publishing Limited*.

Charmaz, K. (2009). Shifting the grounds: Grounded theory in the 21st century. *JM Morse et al.(2009). Developing grounded theory: The second generation*, 125-140.

Christian, M. S., Bradley, J. C., Wallace, J. C., and Burke, M. J. (2009). Workplace safety: a meta-analysis of the roles of person and situation factors.

Chughtai, A. A. (2015). Creating safer workplaces: The role of ethical leadership. *Safety science*, *73*, 92-98.

Clarke, S. (2006). The relationship between safety climate and safety performance: a meta-analytic review.

Clarke, S. (2013). Safety leadership: A meta-analytic review of transformational and transactional leadership styles as antecedents of safety behaviours. *Journal of occupational and organizational psychology*, *86*(1), 22-49.

Cooper, M. D., and Phillips, R. A. (2004). Exploratory analysis of the safety climate and safety behavior relationship. *Journal of safety research*, *35*(5), 497-512.

Feng, Y., Teo, E. A. L., Ling, F. Y. Y., and Low, S. P. (2014). Exploring the interactive effects of safety investments, safety culture and project hazard on safety performance: An empirical analysis. *International journal of project management*, *32*(6), 932-943.

Flin, R., Mearns, K., O'Connor, P., and Bryden, R. (2000). Measuring safety climate: identifying the common features. *Safety science*, *34*(1), 177-192.

Flin, R. (2007). Measuring safety culture in healthcare: A case for accurate diagnosis. *Safety science*, *45*(6), 653-667.

Gardner, A., McCutcheon, H., and Fedoruk, M. (2012). Discovering constructivist grounded theory's fit and relevance to researching contemporary mental health nursing practice. *Australian journal of advanced nursing, The*, *30*(2), 66.

Glaser, B. G. (1967). Strauss. *The discovery of grounded theory. Chicaco (IL): Aldine*.

Goulding, C. (2002). *Grounded theory: A practical guide for management, business and market researchers*. Sage.

Griffin, M. A., and Neal, A. (2000). Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge, and motivation. *Journal of occupational health psychology*, *5*(3), 347.

Guldenmund, F. W. (2000). The nature of safety culture: a review of theory and research. *Safety science*, *34*(1), 215-257.

Hale, A. R., Guldenmund, F. W., Van Loenhout, P. L. C. H., and Oh, J. I. H. (2010). Evaluating safety management and culture interventions to improve safety: Effective intervention strategies. *Safety science*, *48*(8), 1026-1035.

Hofmann, D. A., and Stetzer, A. (1996). A cross-level investigation of factors influencing unsafe behaviors and accidents. *Personnel psychology*, *49*(2), 307-339.

Hoffmeister, K., Gibbons, A. M., Johnson, S. K., Cigularov, K. P., Chen, P. Y., and Rosecrance, J. C. (2014). The differential effects of transformational leadership facets on employee safety. *Safety science*, *62*, 68-78.

Hood, J. C. (2007). Orthodoxy vs. power: The defining traits of grounded theory. *The Sage handbook of grounded theory*, 151-164.

House, R. J., Rousseau, D. M., and Thomas-Hunt, M. (1995). The third paradigm: Meso organizational research comes to age. *Research in organizational behavior*, *17*, 71-114.

Kath, L. M., Magley, V. J., and Marmet, M. (2010). The role of organizational trust in safety climate's influence on organizational outcomes. *Accident Analysis and Prevention*, *42*(5), 1488-1497.

Klein, K. J., Dansereau, F., and Hall, R. J. (1994). Levels issues in theory development, data collection, and analysis. *Academy of management review*, *19*(2), 195-229.

Klein, K. J., Dansereau, F., and Hall, R. J. (1994). Levels issues in theory development, data collection, and analysis. *Academy of management review*, *19*(2), 195-229.

Kozlowski, S. W., and Klein, K. J. (2000). A multilevel approach to theory and research in organizations: Contextual, temporal, and emergent processes. In K. J. Kline and S. W.

Kozlowski (Eds.), Multilevel theory, research, and methods in organizations (pp. 3–90). San Francisco: Jossey-Bass.

Kuenzi, M., and Schminke, M. (2009). Assembling fragments into a lens: A review, critique, and proposed research agenda for the organizational work climate literature. *Journal of management*, 35(3), 634-717.

Lal, S., Suto, M., and Ungar, M. (2012). Examining the potential of combining the methods of grounded theory and narrative inquiry: A comparative analysis. *The qualitative report*, 17(21), 1.

Lauridsen, E. I., and Higginbottom, G. (2014). The roots and development of constructivist grounded theory. *Nurse researcher*, 21(5), 8-13.

Lingard, L., Albert, M., and Levinson, W. (2008). Grounded theory, mixed methods, and action research. Bmj, 337(aug07_3), a567-a567.

Makin, A. M., and Winder, C. (2008). A new conceptual framework to improve the application of occupational health and safety management systems. *Safety science*, 46(6), 935-948.

Mearns, K., Whitaker, S. M., and Flin, R. (2003). Safety climate, safety management practice and safety performance in offshore environments. *Safety science*, *41*(8), 641-680.

Milijic, N., Mihajlovic, I., Strbac, N., and Zivkovic, Z. (2013). Developing a questionnaire for measuring safety climate in the workplace in Serbia. *International journal of occupational safety and ergonomics*, 19(4), 631-645.

Mosher, G. A., Keren, N., Freeman, S. A., and Hurburgh Jr, C. R. (2013). Measurement of worker perceptions of trust and safety climate in managers and supervisors at commercial grain elevators. *Journal of agricultural safety and health*, *19*(2), 125.

Mueller, L., DaSilva, N., Townsend, J., and Tetrick, L. (1999). An empirical evaluation of competing safety climate measurement models. In *annual meeting of the Society for Industrial and Organizational Psychology, Atlanta, GA*.

Nahrgang, J. D., Morgeson, F. P., and Hofmann, D. A. (2007, April). Predicting safety performance: a meta-analysis of safety and organizational constructs. In *22nd annual conference of the society for industrial and organizational psychology, New York*.

Neal, A., Griffin, M. A., and Hart, P. M. (2000). The impact of organizational climate on safety climate and individual behavior. Safety science, 34(1), 99-109.

Neal, A., & Griffin, M. A. (2004). Safety climate and safety at work. *The psychology of workplace safety*, 15-34.

Neal, A., and Griffin, M. A. (2006). A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. Journal of applied psychology, 91(4), 946.

Nielsen, M. B., Mearns, K., Matthiesen, S. B., & Eid, J. (2011). Using the Job Demands–Resources model to investigate risk perception, safety climate and job satisfaction in safety critical organizations. *Scandinavian journal of psychology*, *52*(5), 465-475.

O'Dea, A., and Flin, R. (2001). Site managers and safety leadership in the offshore oil and gas industry. *Safety science*, 37(1), 39-57.

O'Reilly, C. A. (1991). Organizational behavior: Where we've been, where we're going. *Annual review of psychology*, 42, 427–458. Pate-Cornell.

Payne, S. C., Bergman, M. E., Beus, J. M., Rodríguez, J. M., and Henning, J. B. (2009). Safety climate: Leading or lagging indicator of safety outcomes?. *Journal of loss prevention in the process industries*, 22(6), 735-739.

Probst, T. M. (2004). Safety and insecurity: exploring the moderating effect of organizational safety climate. *Journal of occupational health psychology*, 9(1), 3.

Reichers, A. E., and Schneider, B. (1990). Climate and culture: An evolution of constructs. In B. Schneider (Ed.), Organizational climate and culture (pp. 5–39). San Francisco: Jossey-Bass.

Sampson, J. M., DeArmond, S., and Chen, P. Y. (2014). Role of safety stressors and social support on safety performance. *Safety science*, *64*, 137-145.

Schneider, B., Bowen, D. E., Ehrhart, M. G., and Holcombe, K. M. (2000). Handbook of organizational culture and climate. In *The climate for service: evolution of a construct* (pp. 21-36). Sage Publications, Thousand Oaks (CA).

Siu, O. L., Phillips, D. R., and Leung, T. W. (2004). Safety climate and safety performance among construction workers in Hong Kong: The role of psychological strains as mediators. *Accident analysis & prevention*, *36*(3), 359-366.

Shannon, H. S., and Norman, G. R. (2009). Deriving the factor structure of safety climate scales. *Safety science*, *47*(3), 327-329.

Smith, G. S., Huang, Y. H., Ho, M., and Chen, P. Y. (2006). The relationship between safety climate and injury rates across industries: The need to adjust for injury hazards. *Accident analysis and prevention*, 38(3), 556-562.

Tholén, S. L., Pousette, A., and Törner, M. (2013). Causal relations between psychosocial conditions, safety climate and safety behaviour–A multi-level investigation. *Safety science*, *55*, 62-69.

Wertz, F. (2011). Phenomenological Research Methods Psychology: A Comparison with Grounded Theory, Discourse Analysis, Narrative Research, and Intuitive Inquiry.

Whitener, E. M., Brodt, S. E., Korsgaard, M. A., and Werner, J. M. (1998). Managers as initiators of trust: An exchange relationship framework for understanding managerial trustworthy behavior. *Academy of management review*, 23(3), 513-530.

Wu, T. C., Chen, C. H., and Li, C. C. (2008). A correlation among safety leadership, safety climate and safety performance. *Journal of loss prevention in the process industries*, 21(3), 307-318.

Zohar, D. (1980). Safety climate in industrial organizations: theoretical and applied implications. *Journal of applied psychology*, 65(1), 96.

Zohar, D. (2000). A group-level model of safety climate: testing the effect of group climate on microaccidents in manufacturing jobs. *Journal of applied psychology*, 85(4), 587.

Zohar, D. (2002). The effects of leadership dimensions, safety climate, and assigned priorities on minor injuries in work groups. *Journal of organizational behavior*, 23(1), 75-92.

Zohar, D. (2002). Modifying supervisory practices to improve subunit safety: a leadership-based intervention model. *Journal of applied psychology*, 87(1), 156.

Zohar, D., and Luria, G. (2003). The use of supervisory practices as leverage to improve safety behavior: A cross-level intervention model. *Journal of safety research*, 34(5), 567-577.

Zohar, D., and Luria, G. (2004). Climate as a social-cognitive construction of supervisory safety practices: scripts as proxy of behavior patterns. *Journal of applied psychology,* 89(2), 322.

Zohar, D., and Luria, G. (2005). A multilevel model of safety climate: cross-level relationships between organization and group-level climates. *Journal of applied psychology*, 90(4), 616.

Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. *Accident analysis and prevention*, 42(5), 1517-1522.

Zúñiga, F., Schwappach, D., De Geest, S., and Schwendimann, R. (2013). Psychometric properties of the Swiss version of the nursing home survey on patient safety culture. *Safety science*, 55, 88-118.

CHAPTER 6. GENERAL CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

General Review of Conclusions

The overriding goal of this research was to determine the viability of examining Safety Climate through a research ontology/epistemology and methodology different than what has been done previously to determine if new information could be uncovered to further or more adequately answer what psycho-social/socio-technical factors affect perceptions of safety climate in the workplace. Broadly, the research questions asked:

1. Is the existing safety climate research instrument (ZSCQ) an accurate measure of safety climate in the occupational industries of interest to this research?
2. What role do demographic factors and qualitative aspects such as self-reported assessments of job satisfaction, attitude about pay, etc. play in overall safety climate?
3. Are there gaps in data collection that could be addressed by the development and deployment of a qualitative framework like narrative inquiry?
4. Is Grounded Theory an appropriate epistemology/methodology for the study of a quasi-social phenomena such as safety climate?

Results of the analysis of survey data from the agricultural bulk commodity storage/handling facility as well as those of the university research laboratories indicated that overall, both organizational-level (management) and group-level (supervisors and other employees) influences affect overall safety climate perceptions by employees in the workplace. These results are not unexpected, as the research instrument implemented in both organizational sectors for this research can trace its lineage back to the Zohar Safety Climate

Questionnaire (Zohar and Luria, 2005), which was developed to measure the influences of both levels (organizational and group) on overall safety climate. While the naming of the factors resulting from the modeling of each data set were unique to the particular analysis and were the judgment of the researcher in assigning a label to them, the factors uncovered during the exploratory factor analyses are similar to those found in previous studies using similar survey instruments to measure safety climate perceptions.

Analysis of the demographic and self-assessment data indicated that perceptions of fair pay and overall job satisfaction were statistically significant predictors of overall safety climate perceptions by employees. Results of the narrative collection portion of data collection corroborate this assessment, with all respondents indicating that job satisfaction has an impact on personal or overall safety climate, and 11 of 12 of respondents indicating that perceptions of fair pay have an impact on personal or overall safety climate. Additionally, with the majority of responses indicating that a factor/variable has an impact on a respondent's personal perception or overall perception of safety climate in the workplace, the use of narratives in conjunction with the results of the quantitative analyses indicate that not only are the identified factors/variables *statistically* significant, but also have a *personal* significance to the respondents, further validating the results.

General conclusions from this work emphasize several main points:

1. Overall perceptions of safety climate are influenced by a variety of psycho-social factors such as *Management Commitment to Safety, Supervisor Involvement in Safety, Supervisor Communication Reliability, Positive Safety Actions, Supervisor Dependability, Supervisor Personal Stability, Fair Pay,* and *Job Satisfaction.* Results of narratives confirm that each factor play a role in individual perception of safety climate in the workplace. Specifically:

Management Commitment to Safety – Identified as a factor influencing safety climate perceptions through EFA and confirmed as being influential to safety climate perceptions through narrative collection where 11 of 12 respondents expressed that they felt the senior-level personnel in their organization were currently committed to fostering a positive safety climate or had suggestions of how senior-level personnel could demonstrate their commitment.

Supervisor Involvement in Safety – Identified as a factor influencing safety climate perceptions through EFA and confirmed through narrative collection where all of the respondents had their own ideas of how supervisors *should be* involved in fostering a positive safety climate, or they had first-hand experience in their workplace with a supervisor *who was/is* involved in fostering a positive safety climate.

Supervisor Communication Reliability - Identified as a factor influencing safety climate perceptions through EFA and confirmed through narrative collection where 11 of 12 respondents believed that the reliability/consistency of a supervisor's communication had an impact on safety climate.

Positive Safety Actions - Identified as a factor influencing safety climate perceptions through EFA and confirmed through narrative collection, all respondents either had ideas of what kinds of actions could be taken at work to foster a positive safety climate or were able to recount examples from their own life demonstrating how positive safety actions had helped to foster a positive safety climate in the workplace.

Supervisor Dependability - Identified as a factor influencing safety climate perceptions through EFA and confirmed through narrative collection where 11 of 12 respondents provided examples from their own life demonstrating how the dependability of a supervisor helped to foster a positive safety climate or had ideas how a supervisor being considered dependable could help improve safety climate.

Supervisor Personal Stability - Identified as a factor influencing safety climate perceptions through EFA and confirmed through narrative collection where 11 of 12 respondents provided examples to demonstrate and explain how a supervisor's personality can or does affect the safety climate of a workplace.

Fair Pay – Identified as a statistically significant variable influencing overall safety climate scores for individuals through ANOVA and confirmed through narrative collection where all respondents felt that their own level of satisfaction with the job has a definite impact on the safety climate of the workplace. In 50% of the responses, the respondents either explicitly stated or implied that if multiple people in a facility were unsatisfied at work that safety climate could be negatively impacted in a cumulative manner.

Job Satisfaction – Identified as a statistically significant variable influencing overall safety climate scores for individuals through ANOVA and confirmed through narrative collection with 11 of 12 respondents indicating that they felt that being paid fairly had an impact on safety climate in the workplace.

2. While assessment of the underlying factors influencing overall safety climate perceptions can be accomplished through the use of quantitative measures and analysis, determining the depth or extent to which those factors influence safety climate perception has been lacking in previous research studies. Use of narratives (qualitative) in conjunction with quantitative analysis allows the researcher to not only identify which factors potentially influence safety climate perceptions statistically, but to confirm these results through qualitative exploration.

3. Mixed-methods research which combines quantitative research for the identification of

influential factors and qualitative research which can use data collection methods such as narrative collection, can help to further validate an established research instrument like the ZSCQ which has been used extensively to assess safety climate. This additional data collection and comparison could allow for further refinement of research questions in future studies if one or more factors exhibits a particularly strong influence on safety climate perceptions.

4. An Informed, Constructivist Grounded Theory is a valid ontology/epistemology and methodological approach to exploring safety climate perceptions through its inherent use of continual data collection and formulation of explanatory theory after data has been analyzed – to develop a theory which explains rather than a hypothesis to be tested against.

Limitations

The manuscripts comprising the previous three chapters have discussed many of the limitations of the study, yet another review of them will help to remind the reader of the constraints of the conclusions noted above.

The data sets used for this research study were pre-existing and were collected in 2011 and 2015. Inherent in using pre-existing data, the limitations of those data collection procedures (limitation of sample size, the introduction of selection bias, difficulty encouraging participation in research study, etc.) were present as evidenced by the low response rate of both data sets. The Mosher (2011) study's participant-to-question ratio was significantly higher than the Simpson (2015) study, allowing for easier fitting of model and better fit statistics, while the Simpson (2015) data and its lower participant-to question ratio resulted in a model with more factors which required the elimination of many more cross loading variables to achieve an acceptable model fit, yet still resulted in marginally acceptable fit statistics.

The collection of narratives, accomplished from a random sample of current employees from both industry segments, was performed years after the initial safety climate questionnaire data was collected, which could lead a reader to question whether or not these two types of data collection can be collected years apart and be valid and reliable. An assumption was made that the population of workers in each industry segment is roughly homogeneous and had not experienced drastic changes in safety climate perceptions over the period of a few years. This assumption was made in order to carry out both parts of the mixed-methods study in order to demonstrate the validity of using a novel approach in ontology/epistemology and methodology in exploring the factors that influence overall safety climate perceptions.

Through limited respondents in the original data collections used for the quantitative portion of this study, as well as the limited number of narratives collected from current workers in the two industry segments, the question regarding the applicability and generality of this study's results to a larger population becomes one that must be addressed. While the overall goal of this research was to demonstrate the viability of using a novel approach in ontology/epistemology and methodology to studying a topic in safety and health that has historically been studied using a realist/positivist epistemology, the researcher believes that the factors uncovered through the quantitative analysis are similar to those found in previous research studies and the information gathered though the narratives collected correlates to those identified factors – and through these two groups of data, the results of this study could be generalized to a larger population in either of the industry segments used in this research.

Generalizing this study's results to the overall population of all industries and all workers is, in this researcher's opinion, questionable. If one would assume that safety climate perceptions and the factors that influence them are roughly homogeneous, then it could be postulated that this study's results could be generalized to a much larger population of workers and industry segments. However, as the primary goal of this research was to determine the potential viability of mixed-methods research when researching safety climate perceptions, confidently putting forth any conjecture about the ability of this research to be generalized is premature.

Recommendations for Future Work

This research combined both quantitative and qualitative measures of data collection under an Informed, Constructivist Grounded Theory ontology/epistemology and methodology. While some initial findings have been produced, this research has raised a number of questions. Some of these questions might be addressed in future research. Recommendations for future research include:

1. Expansion of the data collection through both quantitative and qualitative methods. Strive to have sufficient respondents to the safety climate questionnaire to surpass this study's respondent-to question ratio provide an ample amount of data for fitting of a model through exploratory factor analysis. Additionally, if a researcher wished to make the assumption of homogeneity regarding workers, combining survey data from multiple assessments from different industries into one larger data set might be carried out for analysis and examination of results.
2. Once factors have been identified through the factor analysis, follow up with the

respondents as soon as feasible to collect narratives from as many subjects as possible so that data collected through both quantitative and qualitative methods are from the same pool of participants during the same segment of time.

3. Expand research to include additional regional areas, including countries, to aid in determining whether factors identified are “universal” across a broad working population or if there are distinct regional/national differences that should be investigated further.

Understanding worker perceptions of safety climate in the workplace and the factors that influence those perceptions have been and will continue to be an important focus of researchers seeking to improve safety management systems, improving measurable safety metrics, and overall improvement of the workplace for employees, supervisors, and management. The research discussed in this manuscript is only the beginning of what can potentially be learned by exploring safety climate perceptions through a new perspective and approach to the research topic, however this research has established a grounding for further work in this area.

REFERENCES

Agnew, C., Flin, R., and Mearns, K. (2013). Patient safety climate and worker safety behaviours in acute hospitals in Scotland. *Journal of safety research*, *45*, 95-101.

Armeli, S., Eisenberger, R., Fasolo, P., and Lynch, P. (1998). Perceived organizational support and police performance: the moderating influence of socioemotional needs. *Journal of applied psychology*, *83*(2), 288.

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological bulletin*, *107*(2), 238.

Beus, J. M., Payne, S. C., Bergman, M. E., and Arthur Jr, W. (2010). Safety climate and injuries: an examination of theoretical and empirical relationships.

Boudrias, J. S., Gaudreau, P., Savoie, A., and Morin, A. J. (2009). Employee empowerment: From managerial practices to employees' behavioral empowerment. *Leadership and organization development journal*, *30*(7), 625-638.

Browne, M. W., and Cudeck, R. (1993). Alternative ways of assessing model fit. *Sage focus editions*, *154*, 136-136.

Bryden, R. (2002, January). Getting serious about safety: Accountability and leadership-the forgotten elements. In *SPE International conference on health, safety and environment in oil and gas exploration and production*. Society of Petroleum Engineers.

Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook*, Census of Fatal Occupational Injuries Summary, 2016, on the Internet at https://www.bls.gov/news.release/cfoi.nr0.htm (visited 1/7/2018).

Christian, M. S., Bradley, J. C., Wallace, J. C., and Burke, M. J. (2009). Workplace safety: a meta-analysis of the roles of person and situation factors.

Chughtai, A., Byrne, M., and Flood, B. (2015). Linking ethical leadership to employee well-being: The role of trust in supervisor. *Journal of business ethics*, *128*(3), 653-663.

Clarke, S., 2006. The relationship between safety climate and safety performance: A meta-analytic review. *Journal of occupational health psychology 11*, 315–327.

Cooper, M. D., and Phillips, R. A. (2004). Exploratory analysis of the safety climate and safety behavior relationship. *Journal of safety research*, *35*(5), 497-512.

Colangelo, P. and Bowers, S. (2012). 5 critical components of safety leadership. on the Internet at https://www.clicksafety.com/docs/whitepapers/5-critical-components-of-safety-leadership.pdf?sfvrsn=4 (visited 1/7/2018).

Cole, M. S., Schaninger Jr, W. S., and Harris, S. G. (2002). The workplace social exchange network: A multilevel, conceptual examination. *Group and organization management*, *27*(1), 142-167.

Conchie, S. M., Moon, S., and Duncan, M. (2013). Supervisors' engagement in safety leadership: Factors that help and hinder. *Safety science*, *51*(1), 109-117.

Coyle-Shapiro, J., and Kessler, I. (2000). Consequences of the psychological contract for the employment relationship: A large scale survey. *Journal of management studies*, *37*(7), 903-930.

O'Dea, A., and Flin, R. (2001). Site managers and safety leadership in the offshore oil and gas industry. *Safety science*, *37*(1), 39-57.

DeJoy, D. M. (2005). Behavior change versus culture change: Divergent approaches to managing workplace safety. *Safety science*, *43*(2), 105-129.

DeJoy, David M., Lindsay J. Della, Robert J. Vandenberg, and Mark G. Wilson. "Making work safer: Testing a model of social exchange and safety management." *Journal of safety research* 41, no. 2 (2010): 163-171.

O'Dea, A., and Flin, R. (2001). Site managers and safety leadership in the offshore oil and gas industry. *Safety science*, *37*(1), 39-57.

Du, X., and Sun, W. (2012). Research on the relationship between safety leadership and safety climate in coalmines. *Procedia engineering*, *45*, 214-219.

Eid, J., Mearns, K., Larsson, G., Laberg, J. C., and Johnsen, B. H. (2012). Leadership, psychological capital and safety research: Conceptual issues and future research questions. *Safety science*, *50*(1), 55-61.

Eisenberger, R., Huntington, R., Hutchison, S., and Sowa, D. (1986). Perceived organizational support. *Journal of applied psychology*, *71*(3), 500.

Eisenberger, R., Armeli, S., Rexwinkel, B., Lynch, P. D., and Rhoades, L. (2001). Reciprocation of perceived organizational support. *Journal of applied psychology*, *86*(1), 42.

Fernández-Muñiz, B., Montes-Peón, J. M., and Vázquez-Ordás, C. J. (2009). Relation between occupational safety management and firm performance. *Safety science*, *47*(7), 980-991.

Fernández-Muñiz, B., Montes-Peón, J. M., and Vázquez-Ordás, C. J. (2014). Safety leadership, risk management and safety performance in Spanish firms. *Safety science*, *70*, 295-307.

Flin, R., Mearns, K., O'Connor, P., and Bryden, R. (2000). Measuring safety climate: identifying the common features. *Safety science*, *34*(1), 177-192.

Forrester, R. (2000). Empowerment: Rejuvenating a potent idea. *The academy of management executive*, *14*(3), 67-80.

Griffin, M. A., and Neal, A. (2000). Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge, and motivation. *Journal of occupational health psychology*, *5*(3), 347.

Guldenmund, F. W. (2000). The nature of safety culture: a review of theory and research. *Safety science*, *34*(1), 215-257.

Guldenmund, F. W. (2007). The use of questionnaires in safety culture research–an evaluation. *Safety science*, *45*(6), 723-743.

Hair J, Anderson RE, Tatham RL, Black WC. (1995). Multivariate data analysis. 4th ed. New Jersey: Prentice-Hall Inc.

Hale, A. R., Heming, B. H. J., Carthey, J., and Kirwan, B. (1997). Modelling of safety management systems. *Safety science*, *26*(1), 121-140.

Hale, A. (2009). Why safety performance indicators?. *Safety science*, *47*(4), 479-480.

Hale, A. R., Guldenmund, F. W., Van Loenhout, P. L. C. H., and Oh, J. I. H. (2010). Evaluating safety management and culture interventions to improve safety: Effective intervention strategies. *Safety science*, *48*(8), 1026-1035.

Harms-Ringdahl, L. (2009). Analysis of safety functions and barriers in accidents. *Safety science*, *47*(3), 353-363.

Haukelid, K. (2008). Theories of (safety) culture revisited—An anthropological approach. *Safety science*, *46*(3), 413-426.

Hinze, J., Thurman, S., and Wehle, A. (2013). Leading indicators of construction safety performance. *Safety science*, *51*(1), 23-28.

Hofmann, D. A., and Stetzer, A. (1998). The role of safety climate and communication in accident interpretation: Implications for learning from negative events. *Academy of management journal*, *41*(6), 644-657.

Hofmann, D. A., and Morgeson, F. P. (1999). Safety-related behavior as a social exchange: The role of perceived organizational support and leader–member exchange. *Journal of applied psychology*, *84*(2), 286.

Hohn, T., and Duden, D. (2009, January). Benchmarking Your Leading Safety Indicators to Manage Jobsite Risk. In *ASSE professional development conference and exhibition*. American Society of Safety Engineers.

Hsu, Y. L., Li, W. C., and Chen, K. W. (2010). Structuring critical success factors of airline safety management system using a hybrid model. *Transportation research part E: logistics and transportation review*, *46*(2), 222-235.

Hu, L., and Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling*, *6*(1), 1-55.

Hubbard, E. E. (2004). The Diversity Scorecard. Evaluating the Impact of Diversity on Organizational Performance. Burlington, MA

Hurst, N. W., Young, S., Donald, I., Gibson, H., and Muyselaar, A. (1996). Measures of safety management performance and attitudes to safety at major hazard sites. *Journal of loss prevention in the process industries*, *9*(2), 161-172.

Hurst, N. (1997). From research to practical tools—developing assessment tools for safety management and safety culture. *Journal of loss prevention in the process industries*, *10*(1), 63-66.

Johnson, S. E. (2007). The predictive validity of safety climate. *Journal of safety research*, *38*(5), 511-521.

Jolliffe, I. T. (1972). Discarding variables in a principal component analysis. I: Artificial data. *Applied statistics*, 160-173.

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and psychological measurement*, *20*(1), 141-151.

Kapp, E. A. (2012). The influence of supervisor leadership practices and perceived group safety climate on employee safety performance. *Safety science*, *50*(4), 1119-1124.

Kath, L. M., Magley, V. J., and Marmet, M. (2010). The role of organizational trust in safety climate's influence on organizational outcomes. *Accident analysis and prevention*, *42*(5), 1488-1497.

Kenny, M., and Fourie, R. (2015). Contrasting classic, Straussian, and constructivist Grounded Theory: Methodological and philosophical conflicts. *The qualitative report*, *20*(8), 1270.

Kongsvik, T., Almklov, P., and Fenstad, J. (2010). Organisational safety indicators: some conceptual considerations and a supplementary qualitative approach. *Safety science*, *48*(10), 1402-1411.

Künzle, B., Kolbe, M., and Grote, G. (2010). Ensuring patient safety through effective leadership behaviour: a literature review. *Safety science*, *48*(1), 1-17.

Lal, S., Suto, M., and Ungar, M. (2012). Examining the potential of combining the methods of grounded theory and narrative inquiry: A comparative analysis. *The qualitative report*, *17*(21), 1.

Liou, J. J., Yen, L., and Tzeng, G. H. (2008). Building an effective safety management system for airlines. *Journal of air transport management*, *14*(1), 20-26.

Lingard, L., Albert, M., and Levinson, W. (2008). Grounded theory, mixed methods, and action research. *Bmj*, *337*(aug07_3), a567-a567.

Lu, C. S., and Yang, C. S. (2010). Safety leadership and safety behavior in container terminal operations. *Safety science*, *48*(2), 123-134.

Luria, G., and Morag, I. (2012). Safety management by walking around (SMBWA): A safety intervention program based on both peer and manager participation. *Accident analysis and prevention*, *45*, 248-257.

Mathieu, J. E., and Zajac, D. M. (1990). A review and meta-analysis of the antecedents, correlates, and consequences of organizational commitment. *Psychological bulletin*, *108*(2), 171.

Mearns, K. J., and Reader, T. (2008). Organizational support and safety outcomes: An un-investigated relationship?. *Safety science*, *46*(3), 388-397.

Meyer, J. P., Stanley, D. J., Herscovitch, L., and Topolnytsky, L. (2002). Affective, continuance, and normative commitment to the organization: A meta-analysis of antecedents, correlates, and consequences. *Journal of vocational behavior*, *61*(1), 20-52.

Michael, J. H., Guo, Z. G., Wiedenbeck, J. K., and Ray, C. D. (2006). Production supervisor impacts on subordinates' safety outcomes: An investigation of leader-member exchange and safety communication. *Journal of safety research*, *37*(5), 469-477.

Mosher, G. A. (2011). *Measurement and analysis of the relationship between employee perceptions and safety and quality decision-making in the country grain elevator*. (Doctoral dissertation, Iowa State University).

Mosher, G. A., Keren, N., Freeman, S. A., and Hurburgh Jr, C. R. (2013). Measurement of worker perceptions of trust and safety climate in managers and supervisors at commercial grain elevators. *Journal of agricultural safety and health*, *19*(2), 125.

Mueller, L., DaSilva, N., Townsend, J., and Tetrick, L. (1999). An empirical evaluation of competing safety climate measurement models. In *annual meeting of the Society for Industrial and Organizational Psychology, Atlanta, GA*.

Nahrgang, J.D., Morgeson, F.P., Hofmann, D.A., 2008. Predicting safety performance: a meta-analysis of safety and organizational constructs. In: *Presented at the Annual Meeting of the Society for Industrial and Organizational Psychology, San Francisco,* April.

Neal, A., Griffin, M. A., and Hart, P. M. (2000). The impact of organizational climate on safety climate and individual behavior. *Safety science*, *34*(1), 99-109.

Neal, A., and Griffin, M. A. (2006). A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. *Journal of applied psychology*, *91*(4), 946.

Øien, K., Utne, I. B., and Herrera, I. A. (2011). Building safety indicators: Part 1–theoretical foundation. *Safety science*, *49*(2), 148-161.

Parker, S. K., Wall, T. D., and Cordery, J. L. (2001). Future work design research and practice: Towards an elaborated model of work design. *Journal of occupational and organizational psychology*, *74*(4), 413-440.

Payne, S. C., Bergman, M. E., Beus, J. M., Rodríguez, J. M., and Henning, J. B. (2009). Safety climate: Leading or lagging indicator of safety outcomes?. *Journal of loss prevention in the process industries*, *22*(6), 735-739.

Piccolo, R. F., and Colquitt, J. A. (2006). Transformational leadership and job behaviors: The mediating role of core job characteristics. *Academy of management journal*, *49*(2), 327-340.

Reiman, T., Pietikäinen, E. (2010). Indicators of Safety Culture – Selection and Utilization of Leading Safety Performance Indicators. Swedish Radiation Safety Authority, Research Report.

Reiman, T., Pietikäinen, E. (2012). Leading Indicators of System Safety—Monitoring and Driving the Organizational Safety Potential. *Safety science. 50* (10), 1993–2000.

Rhoades, L., and Eisenberger, R. (2002). Perceived organizational support: a review of the literature.

Rochlin, G. I. (1996). Reliable organizations: present research and future directions. *Journal of contingencies and crisis management*, *4*(2), 55-59.

Rokeach, M. (1979). Some unresolved issues in theories of beliefs, attitudes, and values. In *Nebraska symposium on motivation*. University of Nebraska Press.

Schaufeli, W. B., and Bakker, A. B. (2004). Job demands, job resources, and their relationship with burnout and engagement: A multi-sample study. *Journal of organizational behavior*, *25*(3), 293-315.

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., and King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of educational research*, *99*(6), 323-338.

Shannon, H. S., and Norman, G. R. (2009). Deriving the factor structure of safety climate scales. *Safety science*, *47*(3), 327-329.

Simpson, S. A. (2015). *A study of safety climate and employees' trust of their organizational leadership in university research laboratories* (Doctoral dissertation, Iowa State University).

Sinelnikov, S., Inouye, J., and Kerper, S. (2015). Using leading indicators to measure occupational health and safety performance. *Safety science*, *72*, 240-248.

Smith, G. S., Huang, Y. H., Ho, M., and Chen, P. Y. (2006). The relationship between safety climate and injury rates across industries: The need to adjust for injury hazards. *Accident analysis and prevention*, *38*(3), 556-562.

Spreitzer, G. M. (1996). Social structural characteristics of psychological empowerment. *Academy of management journal*, *39*(2), 483-504.

Strauch, B. (2015). Can we examine safety culture in accident investigations, or should we?. *Safety science*, *77*, 102-111.

Steiger, J. H. (1990). Structural model evaluation and modification: An interval estimation approach. *Multivariate behavioral research*, *25*(2), 173-180.

Tabachnick BG, Fidell LS. (2007). Using Multivariate Statistics. Boston: Pearson Education Inc.

Tholén, S. L., Pousette, A., and Törner, M. (2013). Causal relations between psychosocial conditions, safety climate and safety behaviour–A multi-level investigation. *Safety science*, *55*, 62-69.

Verbeke, W., Volgering, M., and Hessels, M. (1998). Exploring the conceptual expansion within the field of organizational behaviour: Organizational climate and organizational culture. *Journal of management studies*, *35*(3), 303-329.

Walumbwa, F. O., Cropanzano, R., and Goldman, B. M. (2011). How leader–member exchange influences effective work behaviors: Social exchange and internal–external efficacy perspectives. *Personnel psychology*, *64*(3), 739-770.

Whitener, E. M., Brodt, S. E., Korsgaard, M. A., and Werner, J. M. (1998). Managers as initiators of trust: An exchange relationship framework for understanding managerial trustworthy behavior. *Academy of management review*, *23*(3), 513-530.

Williams, B., Onsman, A., & Brown, T. (2010). Exploratory factor analysis: A five-step guide for novices. *Australasian journal of paramedicine*, *8*(3).

Wu, T. C., Liu, C. W., and Lu, M. C. (2007). Safety climate in university and college laboratories: Impact of organizational and individual factors. *Journal of safety research*, *38*(1), 91-102.

Wu, T. C., Chen, C. H., and Li, C. C. (2008). A correlation among safety leadership, safety climate and safety performance. *Journal of loss prevention in the process industries*, *21*(3), 307-318.

Yukl, G. A., and Becker, W. S. (2006). Effective empowerment in organizations. *Organization management journal*, *3*(3), 210-231.

Zohar, D. (1980). Safety climate in industrial organizations: theoretical and applied implications. *Journal of applied psychology*, *65*(1), 96.

Zohar, D. (2000). A group-level model of safety climate: testing the effect of group climate on microaccidents in manufacturing jobs. *Journal of applied psychology*, *85*(4), 587.

Zohar, D., and Luria, G. (2003). The use of supervisory practices as leverage to improve safety behavior: A cross-level intervention model. *Journal of safety research*, *34*(5), 567-577.

Zohar, D., and Luria, G. (2005). A multilevel model of safety climate: cross-level relationships between organization and group-level climates. *The Journal of applied psychology*, *90*(4), 616-628.

Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. *Accident analysis and prevention*, *42*(5), 1517-1522.

APPENDIX A

ORGANIZATION AND GROUP LEVEL SAFETY CLIMATE

as used in Mosher (2011) research study

Please answer the questions below by circling the number which best matches your opinion on the safety climate in this organization. **Mark your answers in the following ways: 1 = Strongly agree, 2 = Agree, 3 = Neutral, 4 = Disagree, and 5 = Strongly disagree.**

Organizational-Level Safety Climate

Please answer the following questions about your organization's top management team.

Top management in this organization…	**1 = Strongly agree** **2 = Agree** **3 = Neutral** **4 = Disagree** **5 = Strongly Disagree**				
React quickly to solve problems when told about safety hazards	1	2	3	4	5
Insist on thorough and regular safety audits and inspections	1	2	3	4	5
Try to continually improve safety levels in each work area	1	2	3	4	5
Provide all the equipment needed to do the job safely	1	2	3	4	5
Are strict about working safely even when work falls behind schedule	1	2	3	4	5
Quickly correct any safety hazard no mater what the cost	1	2	3	4	5
Provide detailed safety reports to workers regarding injuries, near accidents, etc.	1	2	3	4	5
Consider a person's safety behavior when moving or promoting people	1	2	3	4	5
Require each manager to help improve safety in his or her work area	1	2	3	4	5
Invest a lot of time and money in safety training for workers	1	2	3	4	5
Use any available information to improve safety rules	1	2	3	4	5
Listen to workers' ideas on improving safety	1	2	3	4	5
Consider safety when setting production and speed	1	2	3	4	5

schedules					
Provide workers with a lot of information on safety issues	1	2	3	4	5
Regularly hold safety awareness events (meetings, presentations, etc.)	1	2	3	4	5
Give safety personnel the power they need to do their job	1	2	3	4	5

Group Level Safety Climate:
Please answer the following questions about your supervisor or supervisors.

My supervisor(s)	**1 = Strongly agree** **2 = Agree** **3 = Neutral** **4 = Disagree** **5 = Strongly disagree**				
Makes sure we all receive the equipment needed to do the job safely	1	2	3	4	5
Frequently checks to see if we are all obeying safety rules	1	2	3	4	5
Discusses how to improve safety with us	1	2	3	4	5
Uses explanations (not just forced compliance) to get us to act safely	1	2	3	4	5
Emphasizes safety procedures when we are working under pressure	1	2	3	4	5
Frequently tells us about the hazards in our work	1	2	3	4	5
Refuses to ignore safety rules when work falls behind schedule	1	2	3	4	5
Makes sure we follow all safety rules (not just the important ones)	1	2	3	4	5
Insists we obey safety rules when fixing equipment or machines	1	2	3	4	5
Praises workers who pay special attention to safety	1	2	3	4	5
Is strict about safety at the end of the day when we want to go home	1	2	3	4	5
Spends time helping us learn to see problems before they arise	1	2	3	4	5
Frequently talks about safety issues throughout the work week	1	2	3	4	5
Insists we wear our protective equipment even if it is uncomfortable	1	2	3	4	5
Is strict about working safely when we are tired or stressed	1	2	3	4	5
Remind workers who need them to work safely	1	2	3	4	5

Please mark next to the characteristic which best describes you.

41. What is your gender?	_____ Male _____ Female
42. What is your age?	_____ Under 21 years _____ 21 to 30 years _____ 31-40 years _____ 41-50 years _____ 51-60 years _____ 61 years or more
43. How long have you worked for this organization?	_____ Less than 1 year _____ 1-3 years _____ 3-5 years _____ 5-10 years _____ 10-15 years _____ More than 15 years
44. How long have you worked under your current supervisor?	_____ Less than 1 year _____ 1-3 years _____ 3-5 years _____ 5-10 years _____ More than 10 years
45. How much education have you completed?	_____ Some high school _____ High school diploma or equiv. _____ Voc./ Comm. College Program _____ Some College _____ Bachelor's degree _____ Graduate degree
46. How often do you receive safety training as part of your work?	_____Weekly sessions _____ Twice-monthly sessions _____ Monthly sessions _____ Several times a year _____ Yearly _____ Less than once a year _____ Once – when I started my job
47. How fairly do you feel you are paid for what you do	____ Completely fair

in this organization?

_____ Generally fair
_____Somewhat fair
_____ Not very fair
_____ Not at all fair
_____ Completely satisfied

48. In general, how satisfied are you with your job?

_____ Generally satisfied
_____ Somewhat satisfied
_____ Not very satisfied
_____ Not at all satisfied

APPENDIX B
ORGANIZATION AND GROUP LEVEL SAFETY CLIMATE

as used in Simpson (2015) research study

Please answer the questions below by circling the number which best matches your opinion on the safety climate in this organization. **Mark your answers in the following ways: 1 = Strongly agree, 2 = Agree, 3 = Neutral, 4 = Disagree, and 5 = Strongly disagree.**

Organizational-Level Safety Climate
Please answer the following questions about your organization's top management team.

The Principal Investigator of this laboratory...	**1 = Strongly agree** **2 = Agree** **3 = Neutral** **4 = Disagree** **5 = Strongly Disagree**				
Reacts quickly to solve problems when told about safety hazards	1	2	3	4	5
Insists on thorough and regular safety audits and inspections	1	2	3	4	5
Tries to continually improve safety levels in each work area	1	2	3	4	5
Provides all the equipment needed to do the job safely	1	2	3	4	5
Is strict about working safely even when work falls behind schedule	1	2	3	4	5
Quickly corrects any safety hazard no matter what the cost	1	2	3	4	5
Provides detailed safety reports to workers regarding injuries, near accidents, etc.	1	2	3	4	5
Considers a person's safety behavior when moving or promoting people	1	2	3	4	5
Require each laboratory supervisor to help improve safety in his or her work area	1	2	3	4	5
Promotes and encourages safety training for workers	1	2	3	4	5
Uses any available information to improve safety rules	1	2	3	4	5
Listens to workers' ideas on improving safety	1	2	3	4	5
Consider safety when setting research deadlines	1	2	3	4	5

Provides workers with a lot of information on safety issues	1	2	3	4	5
Regularly hold safety awareness events (meetings, presentations, etc.)	1	2	3	4	5
Give safety personnel the power they need to do their job	1	2	3	4	5

Group Level Safety Climate:
Please answer the following questions about your supervisor or supervisors.

My laboratory supervisor(s)	**1 = Rarely or never** **2 = Seldom** **3 = Occasionally** **4 = Usually** **5 = Always or almost always**				
Is consistent in his/her dealings with various and different individuals	1	2	3	4	5
"Stays the course" and persists, over time, in the actions he/she has decided upon	1	2	3	4	5
Will have the same viewpoint tomorrow as he/she does today	1	2	3	4	5
Shares relevant information	1	2	3	4	5
Follows through with actions consistent with what he/she has said	1	2	3	4	5
Acts in the same way, even in different environments	1	2	3	4	5
Says the same thing from one time to the next	1	2	3	4	5
Makes sure information he/she shares is truthful	1	2	3	4	5
Acts as he/she said he/she would in past statements	1	2	3	4	5
Acts the same toward those he/she knows personally as towards those he/she does not know	1	2	3	4	5
Is open with relevant information	1	2	3	4	5
Demonstrates respect for his/her commitments by his/her actions	1	2	3	4	5
Makes sure that what he/she says will take place actually occurs	1	2	3	4	5
Does what he/she says he/she will do	1	2	3	4	5
Tells the same story to each person they speak to	1	2	3	4	5
Delivers on his/her commitments	1	2	3	4	5
Provides correct information about past behavior	1	2	3	4	5
Follows through on promises	1	2	3	4	5
Carries out actions he/she said would be taken	1	2	3	4	5
States future results or outcomes accurately	1	2	3	4	5

Please mark next to the characteristic which best describes you.

What is your gender?	_____ Male _____ Female
What is your age?	_____ Under 21 years _____ 21 to 30 years _____ 31-40 years _____ 41-50 years _____ 51-60 years _____ 61 years or more
What is your native language?	_________________________
How long have you worked for this organization?	_____ Less than 1 year _____ 1-3 years _____ 3-5 years _____ 5-10 years _____ 10-15 years _____ More than 15 years
How long have you worked under your current principal investigator?	_____ Less than 1 year _____ 1-3 years _____ 3-5 years _____ 5-10 years _____ More than 10 years
45. How much education have you completed?	_____ Some high school _____ HS diploma or equiv. _____ Voc./ Comm. College _____ Some College _____ Bachelor's degree _____ Graduate degree
46. How often do you receive safety training as part of your work?	_____Weekly sessions _____ Twice-monthly sessions _____ Monthly sessions _____ Several times a year _____ Yearly _____ Less than once a year _____ Once – when I started my job