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A study of safety climate and employees' trust of their organizational leadership in university research laboratories

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A study of safety climate and employees' trust of their organizational leadership in university research laboratories

by

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DEDICATION

This dissertation is dedicated to

my lovely wife, Susan A. Sandy Simpson, whose care and support for me made my successful completion possible
and

my parents, the late Gloria L. Jones Simpson and Gerald A. Simpson, who instilled in me the drive to achieve my dreams.

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ABSTRACT

Previous studies have documented positive correlations in industrial environments between employee perceptions of trust in their leadership, safety climate, and safety performance. However, no such studies exist for university research laboratory environments even though highly publicized incidents and fatalities have resulted in increased scrutiny of research laboratories. This study explored the relationships among the following four concepts 1) employee perceptions of trust in two levels of leadership—laboratory supervisor and principal investigator, 2) safety climate within the laboratory environment in the same two levels of leadership, 3) injury and illness data, and 4) non-compliance data at a Midwest AAU university. A questionnaire was used to collected employee perceptions of trust and safety climate. Injury, illness, and non-compliance data were obtained from the university. Descriptive statistics, correlations, and regression analysis were used to calculate the relationships between the variables.

The major findings of this study include the following. There was a significant positive relationship between: 1) employee perceptions of trust in the principal investigator and the laboratory supervisor; 2) safety climate for the principal investigator and the laboratory supervisor; and 3) employee perceptions of trust in the principal investigator and the laboratory supervisor with the level of safety climate. Academic department significantly influenced the relationship between: 1) trust and incident rate; and 2) safety climate and incident rate. However, academic department did not influence the relationship between: 1) trust and non-compliances events; and 2) safety climate and non-compliances events. Laboratory type significantly influenced the relationship between trust and non-compliance events, but not between trust and incident rates. Finally, there was no relationship between

academic department and laboratory when looking at employee perceptions of trust and safety climate.

In conclusion, academic departments and laboratory leadership (both the principal investigator and laboratory supervisor) have significant impact on both employee perceptions of trust and safety climate. Effective traditional safety initiatives (e.g., safety training and compliance) are critical components of university safety programs. However, to achieve excellence in safety performance, university leaders and safety professionals must also focus on increasing trust between workers and laboratory leadership and on improving safety climate in academic research laboratories.

CHAPTER 1.
INTRODUCTION TO RESEARCH

Personnel in the university research environment are fraught with competing priorities and reward structures that sometimes appear incongruent. Issues relating to academic freedom, cutting-edge research, publishing novel research findings, seeking to attain tenure, diminishing grant funding sources, and adhering to real or perceived strict regulatory requirements, complicate the research environment. Many times safety or safety practices in university research laboratories are forgotten or ignored by the researcher, laboratory supervisor, and bench worker.

Forgotten safety priorities and unsafe work practices can lead to unfavorable incidents in laboratories. This fact was evident in the events of December 29, 2008 on the University of California, Los Angeles (UCLA) campus and January 7, 2010 on the Texas Tech University campus. The UCLA event led to the death of a 23-year-old chemistry research assistant, Sheharbano (Sheri) Sangji, on January 16, 2009 from injuries sustained in a chemical fire in her laboratory (Kernsley, 2009). On January 7, 2010, Preston Brown, a graduate student in the Chemistry and Biochemistry Department at Texas Tech University, lost three fingers on one hand, had burns on his hands and face, and injured one eye when the high energy chemical he was working with in the laboratory detonated (U.S. Chemical Safety and Hazard Investigation Board [CSB], 2011). These two incidents were independent events, but certainly not isolated events around university research laboratory environments. The Nature Editorial Panel (2011) article “Accidents in Waiting” details these and other recent high profile incidents in the university research environment. The article continues with a warning to “universities and researchers who feel that there are no lessons to learn from such accidents [that they] are a danger to themselves and others" (para. 9).

The United States Chemical Safety and Hazard Investigation Board (CSB), for the first time in its history, took the lead on the biggest investigation into research laboratory safety (Johnson & Kemsley, 2011). Prior to this action, CSB investigated incidents in industrial environments. The State of California Department of Labor Relations Division of Occupational Safety and Health's criminal investigation and subsequent final report (Christensen, 2012) initiated the indictment of the UCLA researcher and chemistry professor, Patrick Harran, by the Los Angeles District Attorney. Dr. Harran was tried on four felony charges for violating workplace safety standards leading to the death of his research associate (Torrice, 2013).

> UCLA chemistry professor Patrick Harran has been ordered Friday to stand trial on felony charges stemming from a laboratory fire that killed staff research assistant Sheharbano "Sheri" Sangji more than four years ago.
>
> Los Angeles Superior Court Judge Lisa Lench denied a defense motion to dismiss the case, which is believed to be the first such prosecution involving a U.S. academic lab accident (Christensen, 2013, "UCLA chemistry professor ordered to stand trial in fatal lab fire," para. 1-2).

Six years after Sheri Sangji's death, Dr. Harran entered into a 10 part deferred prosecution agreement with the Los Angeles District Attorney on June 20, 2014. Dr. Harran acknowledged and accepted responsibility for the laboratory conditions, but did not plead guilty to the felony charges (Benderly, 2014; Torrice & Kemsley, 2014; Lacey, Williams, & Rizzo, 2014). Dr. Harran's agreement, in part, requires him to perform approximately 1600 hours of community service, including the development and teaching of a preparatory chemistry class for South Central Scholars, a volunteer organization working with highly motivated, disadvantaged, high school students for five years as well as payment of a $10,000 to the Grossman Burn Center, where Sheri Sangji died (Benderly, 2014; Lacey, Williams, & Rizzo, 2014). Dr. Harran must also not violate California labor codes and standards. Even though this agreement may have fallen short of convicting Dr. Harran for the death of Ms. Sangji, it has changed the conversation in the academic community around the country (Benderly, 2014).

Five years after the Texas Tech laboratory incident that maimed Preston Brown, there was another explosion in the Texas Tech Chemistry Building causing lacerations and abrasions to four individuals in the vicinity (Ursch, 2015). This incident was believed to have been caused by chemical waste products in the laboratory (Cook, 2015). The incident demonstrated that hazards exist in research laboratories even in facilities where safety issues have garnered national attention.

CSB Chairperson Dr. Moure-Eraso, said in the CSB video *Experimenting with Danger*, "Research conducted at university laboratories is often on the forefront of technology and innovation. It is important that this research continues and thrives. But it must be done within a strong safety culture where preventing hazards is an important value" (U.S. Chemical Safety and Hazard Investigation Board [CSB], 2011).

In the 45 years since the United States Occupational Safety and Health Administration started enacting rules and guidance for safe operations in the workplace, much research has been done in attempting to describe the human and organizational factors impacting safety climate within varied industries. In recent years, research has been conducted into the impact of trust and decision-making on organizational and operational levels of industries. The aforementioned research has shown relationships between employee trust of their organizational leadership and safety climate (Mosher, 2011, 2013; Mosher, Keren, Freeman & Hurburgh, 2013).

There are many studies dealing with the employees' relationship with the different levels of leadership in various industries—for example, automobile manufacturers, agricultural businesses, aviation, chemical, and shipping, to name a few (Mosher, 2011; Burt & Stevenson, 2009; Clarke, 2006; Zohar, 1980). Studies focusing on employee perceptions of safety climate are detailed throughout the literature (Gutiérrez, Emery, Whitehead, & Felknor, 2013; Mosher, 2011, 2013; Mosher et al., 2013; Kath, Magley, & Marmet, 2010). Some of these studies have also investigated the impact of these perceptions on incident rates, changing a supervisor's perceptions and knowledge of safety policies and practices. Some researchers have also developed tools for monitoring and rewarding safety performance (Zohar, 2002; Kath et al., 2010). The use of these tools has resulted in a decrease in the injury rate within some organizations.

Limited research exists regarding how employee trust in laboratory leadership, the laboratory supervisor and principal investigator (i.e. researcher), impact the safety climate in university research laboratories. In fact, the 2012 University of California Center for Laboratory Safety Workshop made no mention of trust relationships in its proceedings, however, they recognized that "specific interactional attributes affect academic research lab safety culture" (Gibson & Wayne, 2013, p. 10). Most recently, Gutiérrez, Emery, Whitehead, and Felknor (2013) developed a safety climate measurement tool specific for university workplace environments ranging from trade workers to professionals encompassing both faculty and staff.

In their study, they commented that research was “absent” in the literature regarding safety climate in this environment (Gutiérrez et al., 2013).

Non-compliance with applicable local, state, and federal regulatory requirements is not addressed in the literature as it relates to employee perceptions of trust and the organizational safety climate. Non-compliance happens when organizations or individuals whether willfully or accidently fail to follow prescribed actions or procedures. Depending on the regulatory agency, non-compliance can range from not completing required training to not following standard operating procedures or protocols. In the case of the UCLA and Texas Tech University incidents, the actions of the research assistant and graduate student were in violation of their university safety training as well as accepted safe laboratory practices spelled out in the reference book, *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals* (National Research Council, 1995).

Literature Review

Measuring Trust and Safety Climate

Trust and safety climate have been studied and tested in many industries and certain findings have been documented. For instance, Luria (2008) found that there is a positive relationship between factors like employee trust of their organizational leadership and the leader’s encouragement to have a safe workplace. Other studies have confirmed that intermediate management has less of an impact on workers’ perceptions and actions than does the organizational management (Mosher et al., 2013; Zohar & Luria, 2005; Thompson, Hilton, & Witt, 1998). To date, there has been no research published on trust and safety climate in the university research laboratory environment.

Measuring Employee Trust

Trust has been defined in many ways in the literature. Mosher (2013) in reviewing trust, safety climate, and employee decision-making, stated that trust is a willingness to rely on someone to do something needed for you that you cannot manage, and a willingness to accept risk associated with that ability to let the other person help (Mosher, 2013; Dirks & Ferrin, 2002; Kramer, 1999; Mayer, Davis, & Schoorman, 1995; Shockley-Zalabak, Ellis, & Wingrad, 2000; Whitener, Brodt, Korsgaard, & Werner, 1998).

The constructs of trust have been defined as cooperation, confidence, and predictability (Mayer et al., 1995). However, Mosher (2013) in her review also details the research that has been done over the past 20 years in attempts to determine the main constructs that define trust. From the literature, 1) consistency, 2) credibility, 3) competence, and 4) concern or benevolence are the four main constructs of trust (Mosher, 2013; Shockley-Zalabak et al., 2000; Whitener et al., 1998). It is important to remember that trust is more than these constructs; there needs to be a relationship between at least two people; the trustor and the trustee (Mayer et al., 1995).

It seems that organizational management and supervisors must develop "trustworthiness" before employees can truly trust (Whitener et al., 1998; Hardin, 1996). Organizations that support and encourage management to develop trusting relationships and reward employees for trusting can be more effective organizations (Whitener et al., 1998).

There are differing operational definitions of trust looking at both in the relationship with the direct supervisor (e.g., laboratory supervisor) and in the relationship with the organizational management (e.g., principal investigator). These relationships will be different from one another

(Luria, 2010; Mayer & Gavin, 2005; Dirks & Ferrin, 2002). Dirks and Ferrin (2002) go on to discover that these relationships lead to differing work outcomes.

Zohar and Luria (2005) and Thompson et al. (1998) explain safety climate in terms of how these relationships differ and why. Basically, the supervisor has a different relationship with management than with the employees and the message and actions of the supervisor do not always follow the intent of the management, leading to inconsistency. Research shows that employee perceptions of safety come more from management than the supervisor with whom they interact on a daily basis (Mosher et al., 2013; Thompson et al., 1998; Zohar & Luria, 2005).

In a final note on trust, Kramer and his colleagues have researched the decline in trust in our society making this study and possible interventions even more significant (Kramer & Pittinsky, 2009; Kramer & Cook, 2004; Kramer, 1999). However, there is nothing in the literature specifically addressing trust relationships in research laboratories.

Measuring Safety Climate

The study of safety climate is well documented and can be traced to Zohar's initial research in this area in 1980 through the researchers studying it today (Zohar, 2010). Safety climate is defined as an organizational instrument that measures employee perceptions about safety compared with other organizational outcomes (Mosher, 2013; Zohar, 2000). Many instruments have been devised to measure and assess safety climate and the impact of management's attitudes toward safety (Clarke, 2006; Hofmann & Morgeson, 1999; Zohar, 1980).

Similar to studies relative to trust, there is a debate regarding the constructs of safety climate; however, safety climate is defined as "shared perceptions of the organization's practices and policies pertaining to safety" (Kath, Magley, & Marmet, 2010, p.1489). Johnson (2007) studied the constructs of safety climate—caring, compliance, and coaching. He concluded that a three factor model for safety climate was preferred. However, the single factor—global safety priority—was acceptable for explaining safety climate due to the high correlations between caring, compliance, and coaching (Johnson, 2007). Like studies of trust, Mosher (2011) found that there is a relationship between employee safety climate perceptions and decision-making. This is important when looking for the reasoning behind the success or failure in organizational safety outcomes.

Researchers have also studied the impact of human and workplace factors such as organizational tenure, coaching supervisors to include safety in their daily communications with employees, visibility of management and supervisors, and leadership (Beus, Bergman, & Payne, 2010; Kines, Andersen, Spangenberg, Mikkelsen, Dyreborg, & Zohar, 2010; Luria, Zohar, & Erev, 2008; Luria, 2008; Zohar, 2003). Daily supervisory safety communication can improve safety climate, safety behaviors, and teamwork (Zohar & Polachek, 2014). Kath et al. (2010) found that there is agreement on the importance of employee perceptions of safety climate and employee trust and comfort in participating in safety communication with their supervisor regarding needs and outcomes. Wu et al. (2008) even studied the critical role that university presidents play in setting and defining safety climate through "coaching, caring and controlling competencies" (p. 253). Finally, Gutiérrez et al. (2013) concluded that improvements in safety climate may come through stronger relationships between the supervisor and employee as well as increased supervisory training.

Given all the trust and safety climate research studies that have been conducted, there is little research in the literature related to employee perceptions of trust and safety climate within university research laboratory environments and the impact of employee, supervisor, and management relationships on safety outcomes for the university research laboratory environment.

Impact of Trust and Safety Climate on Non-compliance and Incidents

Organizational injuries and illnesses have been studied across many industries especially since OSHA collects workplace statistics annually and the Bureau of Labor Statistics, United States Department of Labor, analyzes and reports on that data.

Apler and Karsh (2009) performed a "systematic" review of safety violations literature regarding the healthcare delivery, commercial driving, aviation, mining, railroad, and construction industries. Their review concluded that there was little in the literature regarding the causes of violations. An interesting concept that did emerge from their review was based on the work of Reason et al. (1995), which concluded that some non-compliance events can be the right choice in the mind of the worker (Apler & Karsh, 2009; Reason, Parker, & Lawton, 1995). Keren et al. (2009) also concluded that peer pressure may impact the final safety choice. Apler and Karsh (2009) suggest that rather than blaming the incident or non-compliance event on workers, managers should "strive to understand why they violate so that we can design their work environments to eliminate, or reduce the need for violations or allow violations to happen safely, when they are necessary" (p. 752).

Wu et al. (2007) claimed that safety training would lessen employee risk exposures and improve employee safety behavior, resulting in fewer incidents and non-compliance events. Training can only be effective if management promotes safety in the research laboratory. Understanding group-level perceptions of safety may help explain the variations in safety records for different laboratory groups as well as correlate management practices with incidents (Zohar, 2000).

Research into incident rates and non-compliance events in the research laboratory environment is absent save the Cal/OSHA and CSB investigations into UCLA, and Texas Tech. Generally, based on this author's nearly three decades of experience as a safety professional in the research laboratory environments, most organizations focus on employee safety education and personal protective equipment to reduce non-compliance and incidents. There has been no focus on employee perceptions of trust and safety climate and improving the relationships between employees and the two levels of management present in the university laboratory environment.

Summary of Knowns and Unknowns

Based on the review of the literature regarding employee perceptions of trust in organizational leadership and safety climate, and their impact on workplace incidents and non-compliance events, there are several knowns.

- Employees trust their manager over their line supervisor.
- Employees' improved perception of trust in organizational leadership has a positive impact on organizational safety climate.
- Employees' positive attitude toward safety generally means a safer workplace.

Even though much has been done in many industries to measure and develop improvement strategies for these core knowns, there are a number of unknowns regarding university research laboratory environments. A few of the unknowns are:

- Employee’s trust relationship with organizational leadership has not been studied.
- Organizational safety climate has not been measured in the university research laboratory environment.
- Relationships between trust and safety climate, and incident rates and non-compliance events for the university research laboratories have not been measured.

Research Questions

The long term goal of this research agenda is to improve safety in research laboratories at all colleges and universities. The goals of this study were to evaluate two organizational factors 1) trust and 2) safety climate; and their relationship to incidents and instances of non-compliance in Iowa State University (ISU) research laboratories. Specifically, the study explored the relationships among the following four concepts 1) employee perceptions of trust in two levels of leadership—laboratory supervisor and principal investigator, 2) safety climate within the laboratory environment in the same two levels of leadership, 3) injury and illness data collected through the ISU First Report of Injury (FROI) system, and 4) non-compliance data collected by the ISU Department of Environmental Health and Safety.

The study was guided by the following research objectives and specific research questions:

Objective 1 – Evaluate employee perceptions of trust and safety climate for two levels of leadership, and then determine relationships between employee trust and safety climate in the research laboratory environment. This objective will be addressed by the following research questions:

1. What is the relationship between the level of employee trust in the principal investigator and the laboratory supervisor?

2. What is the relationship between the level of employee ratings of safety climate in the principal investigator and the laboratory supervisor?

3. What is the relationship between the level of employee trust in the principal investigator and the laboratory supervisor with the level of safety climate?

Objective 2 – Evaluate employee perceptions of trust and safety climate and their relationship to incident rate and non-compliance events within university research laboratories. This objective will be addressed by the following research questions:

1. What is the relationship between the level of departmental and group trust with the level of departmental incident rates?

2. What is the relationship between the level of departmental and group safety climate with the level of organizational incident rates?

3. What is the relationship between the level of departmental and group trust with the level of departmental and group compliance rate?

4. What is the relationship between the level of departmental and group safety climate with the level of departmental and group compliance rate?

Objective 3 – Evaluate employee perceptions of trust and safety climate and their relationship to academic department and laboratory type within university research laboratories. This objective will be addressed by the following research questions:

1. What is the relationship between the departmental level strength of safety climate with the group level of safety climate?
2. What is the relationship between the departmental level strength of trust with the group level of trust?

Methodology

Definitions

Departments and Groups

Iowa State University is organized into colleges and service units. For the purposes of this study, the research will only look at factors impacting colleges which are divided into departments, centers and institutes. Specific to this work, the research will probe the departmental structure, which is subdivided into research groups led by principal investigators (researchers), who have laboratory supervisors and laboratory staff working to perform research within assigned laboratory spaces. For purposes of this study, research groups are categorized into radiological, biological or general (chemical and physical) safety focused groups.

Non-Compliance

Local, state and federal entities have jurisdiction regarding the definition of safe work policies, procedures and practices specific to the hazards in the workplace. These entities require registration, certification, training, reporting, and documentation from organizations to prove that they are complying with specified rules, regulations and guidelines. These entities inspect and audit organizations to verify organizational compliance and, based on the findings, may impose corrective actions to mitigate non-compliance. Sometimes, fines may be levied on organizations depending on the severity of non-compliance or the risk to worker and public health and safety.

Research laboratories have had many minor non-compliance events such as not completing required annual safety training. Gutiérrez et al. (2013) explains that due to the unique nature and pressures associated with a research such as environment, there is a potential for significant incidents to occur like an employee exposure to hazardous material or a spill of toxic chemicals.

Incidents

The United States Occupational Safety and Health Administration (OSHA) requires based on 29 CFR 1904, a log to be maintained that documents recordable worker injuries and illnesses and then summarized annually in the OSHA 300 Form (Recording and Reporting Occupational Injuries and Illness, 2001). Also, calculated and reported as part of the form is the Days Away, Restricted, or Transferred (DART) rate. For the purposes of this study, incidents are defined as the injury and illness data reported by employees and their supervisors through the University's First Report of Injury (FROI) system, which is a larger set of data including the incidents required to be reported to OSHA (Iowa State University, 2015).

Participants

Participants in the study included faculty, staff, and students working in research laboratories at Iowa State University. The study surveyed the bench workers, who report to a specific laboratory supervisor and/or principal investigator. Since Iowa State University has approximately 1,500 research laboratories with about 500 principal investigators, this study selected participants from laboratories with particular hazards—chemical, biological, and radiological—associated with their research. Radiological laboratories are the limiting group of the three with about 178 active rooms. There are 379 active biological laboratories and 704 active chemical research laboratories. After performing a power analysis on the group data, assuming alpha = 0.05, power = 0.8, a response rate of 50% and random sampling of laboratories within each group, 160 laboratories were selected. Random sampling of each group was performed to ensure that the subgroups like laser, biosafety level 3 (BSL-3) and x-ray laboratories would be represented in the data analysis. This sampling protocol was strengthened by the fact that these varied research laboratories have similar safety protocols and have the same safety requirements including training, protocol review, waste management, and inventory controls.

Survey Instruments

Two validated survey instruments were combined, modified for the research laboratory environment, and used to measure trust and safety climate to better understand the relationship between employee perceptions of trust and safety climate (Mosher, 2011; Zohar & Luria, 2005; Levin, 1999). Research by Zohar (2000, 2008) on measuring perceptions of human factors like safety climate and leadership, at two levels of management in the workplace were foundational for the study. Employees have differing perceptions of the organizational leader and the employee's supervisor due to the types and ways they communicate, interact, and respond to these management groups (Zohar, 2000, 2008; Mosher, 2011). In other words, the organizational leader sets the direction for the workplace and the supervisor determines the steps to move the group in that direction (Zohar, 2008).

For this study, the Management Behavior Climate Assessment developed by Levin (1999) and validated by Mosher (2011) was used to measure employee perceptions of trust in their management and their supervisor (i.e., principal investigator and laboratory supervisor). This instrument was tested and validated by Levin (1999) in a number of manufacturing, academic, military, and government environments as part of its development. Since that time, other researchers have evaluated other industries including nursing, U.S. Air Force, and grain elevator operators (Lafferty, 2000; Milligan, 2003; Mosher, 2011). This instrument consists of 40 questions using a 5-point Likert-type scale (5 = always or almost always; 4 = usually; 3 = occasionally; 2 = seldom; and 1 = rarely or never) as well as demographic data. Minor modifications to the instrument include defining top management as the principal investigator and supervisor as laboratory supervisor. Mosher (2011) performed confirmatory factor analysis on the data confirming consistency and credibility as the two main factors explaining the concept of trust.

There are two potential choices for the measurement of employee perceptions of safety climate: the Organization and Group Level Safety Climate (Zohar & Luria, 2005) instrument and the University Safety Climate Questionnaire (Gutiérrez, 2011). The University Safety Climate Questionnaire was based on Wu et al. (2007) safety climate instrument and has a broad focus, studying safety climate in the university workplace setting. The survey was administered to five universities within the United States for comparative analysis. Gutierrez (2011) pointed out that future safety climate surveys should focus on major groups within the university. Zohar (2000) developed the group-level model for assessing safety climate in an organization. Zohar and Luria (2005) developed the Organization and Group Level Safety Climate instrument to address the fact that employees are impacted by leadership from more than the group or line level. This instrument has been validated over many industries such as automobile manufacturers, agricultural businesses, aviation, chemical, and shipping (Mosher, 2011). For purposes of this study, the Organization and Group Level Safety Climate instrument was used, since it specifically targets two levels of management within an organization and the University Safety Climate Questionnaire does not. The Organization and Group Level Safety Climate instrument consists of 32 questions using a 5-point Likert-type scale (5 = always or almost always; 4 = usually; 3 = occasionally; 2 = seldom; and 1 = rarely or never) as well as demographic data. Minor modifications to the instrument included defining top management as the principal investigator and supervisor as the laboratory supervisor. Demographic data was collected such as age, gender, education level, safety training experience, and time in the research laboratory environment.

The combined survey was sent to employees of randomly selected research laboratories as an electronic questionnaire including a waived consent form. Completion of the survey was voluntary and anonymity was maintained. A letter from the Provost and Assistant Vice President for the Department of Environmental Health and Safety was sent by email to principal investigators prior to the initial email soliciting participation by laboratory workers encouraging them to have their staff complete the surveys. The initial email explained why the study was relevant and encouraged laboratory worker participation. Three reminder emails were sent approximately two weeks apart to ensure the highest return rates possible.

Statistical Analysis

Basic descriptive statistical analyses (i.e., means and standard deviations) were performed on the data collected from the survey. The data were analyzed as a whole and then separated into group and departmental level results. Simple linear regression analysis was performed on employee perceptions of trust and safety climate data to determine if there is a significant relationship between them in the university research laboratory environment.

Incident and injury data were requested from University Human Resources through the University's First Report of Injury (FROI) system. At Iowa State University, workers and their supervisor are required to report any accidents and injuries to workers on campus including research laboratories. Data collected included, but were not limited to, the type of incident and injury, supervisor, location, and department. The data collected were cleaned to eliminate non-research spaces, then summarized in different categories - incident type, location, and department.

Non-compliance data were collected through laboratory safety surveys conducted by the Environmental Health and Safety department. The data is stored in the department's Laboratory Safety Database to ensure ease of retrieval for inspection by regulatory agencies. The laboratory safety surveys cover a myriad of safety regulatory compliance requirements including written protocols, safety training, chemical, biological and radiological inventory maintenance, and personal protective equipment availability and use. The data collected were cleaned to eliminate non-research spaces, then summarized in different categories—for example, non-compliance event, location, and department. Incident and non-compliance data were compared to trust and safety climate data through simple linear regression to determine any relationships related to the research questions.

Security of all data was maintained electronically on password-protected ISU-supported systems. Names of participants and persons identified in incident and non-compliance data were not collected or were deleted through the data cleaning process.

Institutional Review Board (IRB) Approval

This project was approved by the ISU Institutional Review Board. See Appendix for approval documentation.

Dissertation Organizational Structure

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, literature review of research as a justification for this dissertation research and a summary of research goals and objectives. Chapters two through four are manuscripts formatted for submission to specified journals.

Chapter two—Impact of employees' perceptions of trust and safety climate in the university research laboratory environment at two levels of management—will be submitted to *Safety Science*.

Chapter three—Impact of employees' perceptions of trust and safety climate on incidents and non-compliance events in the university research laboratory environment—will be submitted to the *Journal of Safety Research*.

Chapter four—Impact of group level trust and safety climate on departmental level trust and safety climate—will be submitted to the *Journal of Safety*, *Health and Environmental Research*.

Chapter five is comprised of a general discussion and interpretation of research results, limitations, conclusions, and future research recommendations.

References

Accident Prevention, Reporting, and Investigation, Iowa State University Policy Library (2015).

Apler, S.J. & Karsh, B. (2009). A systematic review of safety violations in industry. *Accident Analysis and Prevention*, 41(4), 739–754.

Benderly, B.L., (2014). The Landmark Patrick Harran Case Ends Inconclusively. *Science Careers from Science*. Retrieved February 14, 2015 from http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2014_07_09/caredit.a1400176

Beus, J.M., Bergman, M.E., & Payne, S.C. (2010). The influence of organizational tenure on safety climate strength: A first look. *Accident Analysis and Prevention*, 42(1), 1431-1437.

Burt, C.D.B., Stevenson, R.J. (2009). The relationship between recruitment processes, familiarity, trust, perceived risk and safety, *Journal of Safety Research*, 40(5), 365-369, doi:10.1016/j.jsr.2009.08.002.

Christensen, K. (2013, April 26). UCLA chemistry professor ordered to stand trial in fatal lab fire. *Los Angeles Times*, 26. Retrieved from http://www.latimes.com http://articles.latimes.com/2013/apr/26/local/la-me-ucla-prof-20130426

Christensen, K. (2012). Report faults professor, UCLA in death of lab assistant. *Los Angeles Times*, 21. Retrieved from http://articles.latimes.com/2012/jan/21/local/la-me-ucla-lab-20120121

Clarke, S. (2006). *Safety climate in an automobile manufacturing* plant: The effects of work environment, job communication and safety attitudes on accidents and unsafe behavior. *Personnel Review*, 35(4), 413-430.

Cook, C. (2015). Minor Explosion at Chemistry Building. *Texas Tech University News*, 02. Retrieved February 2, 2015 from http://today.ttu.edu/2015/02/minor-explosion-at-chemistry-building/

Dirks, K.T. & Ferrin, D.L. (2002). Trust in leadership: Meta-analytic findings and implications for research and practice. *Journal of Applied Psychology*, 87(4), 611-628.

DSS Research (2013). Statistical Power Calculator. Researcher's Toolkit. Retrieved November 20, 2013 from https://www.dssresearch.com/KnowledgeCenter/toolkitcalculators/statisticalpowercalculators.aspx.

Gibson, J.H., & Wayne, N.L. (2013). Proceedings of the 2012 University of California Center for Laboratory Safety Workshop. *Journal of Chemical Health and Safety*, 20(1), 4-17.

Gutierrez, J. M. (2011). A Multi-Site Pilot Test Study to Measure Safety Climate in the University Work Setting. *ProQuest LLC*.

Gutiérrez, J.M., Emery, R.J., Whitehead, L.W., & Felknor, S.A. (2013). A means for measuring safety climate in the university work setting. *Journal of Chemical Health & Safety*, 658, 1-10. doi:10.1016/j.jchas.2013.07.001.

Hardin, R. (1996). Trustworthiness. *Ethics*, 107, 26-42.

Hofmann, D.A., 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), 286–296.

Johnson, J. & Kemsley, J., (2011 October 19). Academic Lab Safety Under Exam. *Chemical & Engineering News*, 89(43). Retrieved from https://pubs.acs.org/cen/government/89/8943gov1.html

Kath, L.M., Magley, V.J., & Marmet, M. (2010). The role of organizational trust in safety climate's influence on organizational outcomes. *Accident Analysis and Prevention*, 42(1), 2010.

Keren, N., Mills, T.R., Freeman, S.A., & Shelley, M.C. (2009). Can level of safety climate predict level of orientation toward safety in a decision-making task? *Safety Science*, 47(10), 1312-1323.

Kernsley, J. (22 January 2009). Researcher Dies After Lab Fire. *Chemical & Engineering News*, *Latest News*. Retrieved from http://cen.acs.org.proxy.lib.iastate.edu/articles/87/web/2009/01/Researcher-Dies-Lab-Fire.html

Kines, P., Andersen, L. P. S., Spangenberg, S., Mikkelsen, K. L., Dyreborg, J., and Zohar, D. (2010). Improving construction site safety through leader-based verbal safety communication, *Journal of Safety Research*, 41, 399-406.

Kramer, R.M. & Pittinsky, T.L. (Eds.). (2009). *Restoring Trust in Organizations and Leaders: Enduring Challenges and Emerging Answers.* Oxford University Press. doi:10.1093/acprof:oso/9780199756087.001.0001

Kramer, R.M. & Cook, K.S. (Eds.). (2004). *Trust and distrust in organizations: Dilemmas and approaches*. Russell Sage Foundation: New York.

Kramer, R.M. (1999). Trust and Distrust in Organizations: Emerging Perspectives, Enduring Questions, *Annual Review Psychology*, 50, 569-598.

Lacey, J., Williams, S.P., and Rizzo, M. (2014). Superior Court of the State of California for the County of Los Angeles, Deferred Prosecution Agreement, Case No. BA 392069.

Retrieved from https://www.documentcloud.org/documents/1202952-2014-06-20-harran-settlemetn-agreement-from-da.html.

Lafferty, C. L. (2003). *Organizational trust in hospital nursing staffs and its relationship to three performance indicators of organizational effectiveness* (Doctoral dissertation, George Washington University).

Levin, S. L. (1999). Development of an instrument to measure organizational trust. *Dissertation Abstracts International, UMI*, (9920326).

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

Luria, G. (2008). Climate strength – How leaders form consensus. *The Leadership Quarterly*, 19, 42-53.

Luria, G., Zohar, D. and Erev, I. (2008). The effect of workers' visibility on effectiveness of intervention programs: Supervisory-based safety interventions, *Journal of Safety Research*, 39, 273-280. doi: 10.1016/j.jsr.2007.12.003

Mayer, R.C. & Gavin, M.B. (2005). Trust in management and performance: Who minds the shop while the employees watch the boss? *Academy of Management Journal*, 48(5), 874-888.

Mayer, R.C., Davis, J.H. & Schoorman, F.D. (1995). An integrative model of organizational trust. *Academy of Management Review*, 20(3), 709-734.

Mosher, G. A., Keren, N., Freeman, S. A. & Hurburgh, C. R. (2013). Employee Trust and Its Influence on Quality Climate at Two Administrative Levels, *Journal of Technology, Management, and Applied Engineering*, 29(2), 2-12.

Mosher, G.A. (2013). Trust, Safety, and Employee Decision-Making: A Review of Research and Discussion of Future Directions, *Journal of Technology, Management, and Applied Engineering*, 29(1), 2-11.

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).

National Research Council (US). Committee on Prudent Practices for Handling, Storage, & Disposal of Chemicals in Laboratories. (1995). Prudent practices in the laboratory: handling and disposal of chemicals. National Academies Press.

Nature Editorial Panel. (2011 April 21). Accidents in waiting. *Nature*, 472, 259. Retrieved from http://www.nature.com.proxy.lib.iastate.edu/nature/journal/v472/n7343/full/472259a.html, doi:10.1038/472259a

Reason, J., Parker, D., Lawton, R. (1995). A systems-approach to organizational error. *Ergonomics* 38 (8), 1708–1721.

Recording and Reporting Occupational Injuries and Illness, 29 C.F.R. pt 1904 (2001).

Shockley-Zalabak, P., Ellis, K., & Winograd, G. (2000). Organizational trust: What it means, why it matters, *Organization Development Journal*, 18, 35-48.

Smith, P. C., Kendall, L., & Hulin, C. L. (1969). *The measurement of satisfaction in work and retirement: A strategy for the study of attitudes*. Chicago: Rand McNally.

Thompson, R.C., Hilton, T.F., Wilt, L.A. (1998). Where the safety rubber meets the shop floor: A confirmatory model of management influence on workplace safety. *Journal of Safety Research*, 29(1), 15-24.

Torrice, M. & Kemsley, J. (2014). Patrick Harran And L.A. District Attorney Reach Deal In Sheri Sangji Case. *Chemical & Engineering News*, 92(26), 4. Retrieved from http://cen.acs.org/articles/92/i26/Patrick-Harran-L-District-Attorney.html

Torrice, M. (2013). Patrick Harran To Face Felony Trial On Labor Code Violations. *Chemical & Engineering News*, 91(18), 9. Retrieved from http://cen.acs.org/articles/91/i18/Patrick-Harran-Face-Felony-Trial.html

Ursch, B. (2015). 4 people injured in explosion in Texas Tech Chemistry Building. *Lubbock Avalanche-Journal*. Retrieved from http://lubbockonline.com/local-news/2015-02-02/4-people-injured-explosion-texas-tech-chemistry-building#.VN-BofmjO-1.

U.S. Chemical Safety and Hazard Investigation Board (CSB). (2011). Case Study: Texas Tech University Lab Explosion, No. 2010-05-I-TX; Retrieved from http://www.csb.gov/assets/1/19/CSB_Study_TTU_.pdf

U.S. Chemical Safety and Hazard Investigation Board (CSB). (2011, October 20). Experimenting with Danger [Video file]; Retrieved from http://www.csb.gov/videos/experimenting-with-danger/

Whitener, E.M., Brodt, S.E., Korsgaard, M.A., & 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., Li, C., Chen, C., & Shu, C. (2008). Interaction effects of organizational and individual factors on safety leadership in college and university laboratories. *Journal of Loss Prevention in the Process Industries*, 21(1), 239-254.

Wu, T.C., Lui, C.W., & 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.

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

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

Zohar, D. (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. (2002). Modifying supervisory practices to improve subunit safety: A leadership-based intervention model. *Journal of Applied Psychology*, 87(1), 156-163.

Zohar, D. (2000). A group-level model of safety climate: Testing the effect of group climate on micro-accidents in manufacturing jobs. *Journal of Applied Psychology*, 85(4), 587-596.

Zohar, D. (1980). Safety climate in industrial organizations: Theoretical and applied implications. *Journal of Applied Psychology*, 65(1), 96-102.

CHAPTER 2.
IMPACT OF EMPLOYEES' PERCEPTIONS OF TRUST AND SAFETY CLIMATE IN THE UNIVERSITY RESEARCH LABORATORY ENVIRONMENT AT TWO LEVELS OF MANAGEMENT

Manuscript to be submitted to the *Journal of Safety Research*

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Abstract

Introduction: Many university research laboratories are managed by a two-tier structure. Organizational leadership comes from the principal investigator and facility management is the role of the laboratory supervisor. These working groups are continually challenged by competing priorities like developing and funding cutting edge research, producing and publishing novel research findings, seeking to attain tenure, managing laboratory staff as well as maintaining a safe and compliant workplace. Employee perceptions of trust in the leadership and safety climate can be negatively impacted when competing priorities stymie safety practices leading to incidents, injuries and non-compliance. This study examines the relationship between perceptions of trust and safety climate including impacts on incident and non-compliance rates. *Method*: Laboratory workers from 460 Iowa State University research laboratories were invited to participate in this study through an electronic questionnaire on perceptions of trust and safety climate. Descriptive statistics, correlations, and regression analysis were used to calculate the relationships between the variables. *Results*: Organizational and laboratory level trust significantly predicts safety climate. Department significantly impacted perceptions of trust and safety climate. *Impact on Research Laboratories*: This study suggests that laboratory workers

perceptions of trust play a role in safety climate as well as supports previous research proposing a two-level safety climate in the work place. Principal investigators and laboratory supervisors must improve their understanding regarding influencing factors if they want to promote a safe working environment for their employees.

Introduction

Personnel in the university research laboratories are continually challenged by competing priorities such as developing and funding cutting edge research, producing and publishing novel research findings, seeking to attain tenure, managing laboratory staff as well as maintaining a safe and compliant workplace. Many times prudent safety practices are overlooked or forgotten in light of the competitive research environment, leading to unsafe work practices and unfavorable incidents or injuries. This fact was evident in the events of December 29, 2008 on the University of California, Los Angeles (UCLA) campus and January 7, 2010 on the Texas Tech University, Lubbock campus. Sheharbano (Sheri) Sangji, chemistry research assistant died 17 days after an incident in which a pyrophoric material, which she was using in her experiment, exploded and caught her clothing on fire (Kemsley, 2009). Preston Brown, a graduate student in the Chemistry and Biochemistry Department at Texas Tech University, lost fingers on one hand, had burns on his hands and face, and injured one of his eyes when the high energy chemical he was working with detonated (U.S. Chemical Safety and Hazard Investigation Board [CSB], 2011).

Dr. Patrick Harran, endowed chair in Organic Chemistry at UCLA and principal investigator for Sheri Sangji at the time of her death, was the first university research laboratory principal investigator to be charged for a laboratory safety incident (Christensen, 2012). Six years after Sheri Sangji's death, Dr. Harran entered into a 10 part deferred prosecution agreement with the Los Angeles District Attorney on June 20, 2014. Dr. Harran acknowledged and accepted responsibility for the laboratory conditions, but did not plead guilty to the felony charges (Benderly, 2014; Torrice & Kemsley, 2014; Lacey, Williams, & Rizzo, 2014). Even though the agreement fell short of convicting Dr. Harran for the death of Ms. Sangji, it has changed the laboratory safety conversation in the academic community around the country (Benderly, 2014). The Nature Editorial Panel article "Accidents in Waiting", details the UCLA and Texas Tech incidents as well as other recent high profile incidents warning universities and researchers that if they believe that there are no lessons to learn from these incidents, they are endangering themselves and others (Nature, 2011).

Safety incidents and violations in the workplace have been studied in many industries for a long time, but university research laboratories have not been the subject of intentional safety research (Gutiérrez et al., 2013). Employee perceptions have been recognized as having an important impact on the workplace including their actions during the workday (Mosher, 2011, Das et al., 2008, Zohar & Luria, 2005). Studies have shown positive relationships between employees' trust of their organizational leadership and safety climate (Mosher, 2013; Mosher, Keren, Freeman & Hurburgh, 2013; Mosher, 2011). Previous studies focused on employees' relationship with different levels of leadership in various industries covering automobile manufacturers, agricultural businesses, aviation, chemical, and shipping (Mosher, 2011; Burt & Stevenson, 2009; Clarke, 2006; Zohar, 1980). Some of these studies have also investigated the impact of these perceptions on incident rates, on changing a supervisor's perceptions and knowledge of safety policies and practices, and on providing tools for monitoring and rewarding safety performance resulting in a decrease in incident and non-compliance rates within the organization. (Zohar, 2002; Kath Magley & Marmet, 2010). However, limited research exists regarding how employees' trust in laboratory leadership impacts safety climate in university research laboratories. Since safe workplaces depend heavily on the decisions employees make on the job (Mosher et al., 2014; Keren, Mills, Freeman & Shelley, 2009; Zohar & Erev, 2007) an increased understanding of employee perceptions of trust and safety climate may provide useful information in the development of specific safety counter measures, best practices for management, or targeted educational intervention.

Trust

Trust is defined as a willingness to rely on someone to do something for you that you cannot manage alone, and a willingness to accept risk associated with that ability to let the other person help (Mosher, 2013; Dirks & Ferrin, 2002; Kramer, 1999; Mayer, Davis, & Schoorman, 1995; Shockley-Zalabak, Ellis, & Wingrad, 2000; Whitener, Brodt, Korsgaard, & Werner, 1998)

Various constructs define trust. Mayer et al. (1995) define trust as cooperation, confidence, and predictability. Subsequent research has demonstrated that 1) consistency, 2) credibility, 3), competence and 4) concern or benevolence are the four main constructs of trust (Mosher, 2013; Shockley-Zalabak et al., 2000; Whitener et al., 1998). In her research, Mosher (2011) confirmed consistency and credibility as main factors explaining the concept of trust. However, it is important to remember that trust is more than constructs. Trust requires a relationship between at least two people; the trustor and the trustee (Mayer et al., 1995).

Trustworthiness must be demonstrated by leadership and management—therefore setting an example for their employees and gaining their trust is critical (Whitener et al., 1998; Hardin, 1996). Organizations that support and encourage management to develop trusting relationships and reward employees for trusting often observe more effective organizations (Whitener et al., 1998). There are differing definitions of trust in the relationship with the direct supervisor (e.g., laboratory supervisor) and trust in the relationship with the organizational management (e.g., principal investigator). These relationships will be different from one another (Luria, 2010; Mayer & Gavin, 2005; Dirks & Ferrin, 2002) and lead to differing work outcomes (Dirks & Ferrin, 2002). This study and possible interventions become more important in the light that previous research has demonstrated a decline in trust in our society (Kramer & Pittinsky, 2009; Kramer & Cook, 2004; Kramer, 1999).

Safety Climate

Safety climate is defined as an organizational instrument that measures employee perceptions toward safety compared with other organizational outcomes (Mosher, 2013; Zohar, 2000). Like trust, there is a debate regarding the constructs of safety climate; however, safety climate is defined as “shared perceptions of the organization's practices and policies pertaining to safety” (Kath, Magley, & Marmet, 2010, p.1489). Many tools have been devised to measure and assess safety climate and the impact of management attitudes toward safety (Clarke, 2006; Hofmann & Morgeson, 1999; Zohar, 1980).

Kath et al. (2010) found that there is agreement regarding the importance of employee perceptions of trust and safety climate and comfort in participating in safety communication with their supervisor regarding needs and outcomes. Researchers have also studied the impact of human and workplace factors such as organizational tenure, coaching supervisors to include safety in their daily communications with employees, visibility of management and supervisors, and leadership (Beus, Bergman & Payne, 2010; Kines, Andersen, Spangenberg, Mikkelsen, Dyreborg & Zohar, 2010; Luria, Zohar & Erev, 2008; Luria, 2008; Zohar, 2003). Gutiérrez et al.

(2013) concluded that improvements in safety climate may come through stronger relationships between the supervisor and employee as well as increased supervisory training.

Trust and Safety Climate

Trust and safety climate have been studied and tested in many industries and certain outcomes have been documented. There is a positive relationship between factors like employee trust of organizational leadership and the leader's encouragement to have a safe workplace (Luria, 2008). Studies also confirm that intermediate management has less of an impact on workers' perceptions and actions than the organizational management (Mosher et al., 2013; Zohar & Luria, 2005; Thompson Hilton & Witt, 1998). To date, there has been no research published on trust and safety climate in university research environments. Little research related to employee perceptions of trust and safety climate within the university research laboratory environment has been documented in the literature.

Methodology

This study endeavors to gain an understanding of the relationship between safety climate and employee perceptions of trust at two tiers of management in the research laboratory environment. This environment consists of principal investigators who provide overall leadership and funding for all laboratory research activities. The laboratory supervisor manages all day to day research activities including training, guiding, and advising the laboratory workers. Based on the knowledge that research laboratories contend with many safety hazards in addition to research challenges, this study seeks to determine if there are differences in groupings of laboratories. These factors include hazards associated with the use of radiation, biologics and chemicals, department cultural influences, age, education, and length of time in the laboratory.

Two validated survey instruments were combined, modified for the research laboratory environment, and used to measure trust and safety climate to better understand the relationship between employee perceptions of trust and safety climate (Mosher, 2011; Zohar & Luria, 2005; Levin, 1999). Research by Zohar (2000, 2008) on measuring perceptions of human factors like safety climate and leadership, at two levels of management in the workplace were foundational for the study. Zohar suggested that employees have differing perceptions of the organizational leader and the employee's supervisor due to the types and ways they communicate, interact, and respond to these management groups (Zohar, 2000; Zohar, 2008; Mosher, 2011). In other words, the organizational leader sets the direction for the workplace and the supervisor determines the steps to move the group in that direction (Zohar, 2008).

For this study, the Management Behavior Climate Assessment developed by Levin (1999) and validated by Mosher (2011) will be used to measure employee perceptions of trust in their management and their supervisors (i.e., principal investigator and laboratory supervisor). This instrument was tested and validated by Levin (1999) in several workplace environments such as manufacturing, academic, military, and government. Since Levin's initial work, other environments have been evaluated including nursing, U.S. Air Force, and grain elevator operators (Lafferty, 2003; Milligan, 2003; Mosher, 2011). This instrument consists of 40 questions using a 5-point Likert-type scale (5 = always or almost always; 4 = usually; 3 = occasionally; 2 = seldom; and 1 = rarely or never) as well as demographic and job satisfaction data. Minor modifications to the instrument include defining top management as the principal investigator and supervisor as laboratory supervisor. Demographic data included age, gender, education level, native language, safety training experience, and time in the research laboratory environment. Mosher (2011) performed confirmatory factor analysis on the data confirming consistency and credibility as two main constructs of trust. Given this understanding, mean response values from worker responses were determined for trust, consistency, and credibility.

There are two potential choices for the measurement of employee perceptions of safety climate: the Organization and Group Level Safety Climate (Zohar & Luria, 2005) instrument and the University Safety Climate Questionnaire (Gutiérrez, 2011). The University Safety Climate Questionnaire is based on Wu et al. (2007) safety climate instrument and has a broad focus, studying safety climate in the university workplace setting. The survey was administered at five universities within the United States for comparative analysis. Gutierrez (2011) pointed out that future safety climate surveys should focus on major groups within the university. Zohar and Luria (2005) developed the Organization and Group Level Safety Climate instrument to determine employee perceptions of safety climate for organizational management and direct supervisor. This instrument has been validated over many industries such as automobile manufacturers, agricultural businesses, aviation, chemical, and shipping (Mosher, 2011; Johnson, 2007). For purposes of this study, the Organization and Group Level Safety Climate instrument was used, since it specifically targets two levels of management within an organization. The Organization and Group Level Safety Climate instrument consisted of 32 questions using a 5-point Likert-type scale (5 = always or almost always; 4 = usually; 3 = occasionally; 2 = seldom; and 1 = rarely or never) as well as demographic data. Minor modifications to the instrument included defining top management as the principal investigator and supervisor as the laboratory supervisor. Mosher (2011) performed a factor analysis on safety climate. Her work confirmed Johnson’s (2007) study determining that one factor could define the safety climate structure adequately. This assertion was validated in Zohar and Luria’s research, too (Zohar & Luria, 2005). Given this understanding, a mean response value from worker responses was used for safety climate in the study's analysis.

The instrument administration was a complex process consisting of several major steps. First, the university has approximately 1,500 research laboratories with about 500 principal investigators, laboratories were selected based on associated hazards—chemical, biological, and radiological—and the overall risk ranking for the research laboratory. The risk ranking was based on audit findings for the facility and the particular severity and frequency of the finding. Findings are based on relevant federal, state and local regulations and guidelines for particular hazards in laboratories. There were approximately 200 radiological laboratories, 400 biological laboratories and 900 chemical research laboratories within the population at the university. Laboratories were stratified based on hazard type and risk level; 160 laboratories of each hazard type were randomly selected for this study. Principal investigators for the selected laboratories received an email memorandum from the University Provost and the Assistant Vice President for the Department of Environmental Health and Safety requesting support for this study. Additionally, they received an email requesting potential participant names and email addresses. The potential participants were emailed a link to the electronic trust and safety climate instrument.

Several statistical methods were used to evaluate the relationship between dependent and independent variables in this study. A comparison of means and variances of the dependent and independent variables, scatterplots of variable means, and bivariate linear regression modeling were used to determine significant relationships between variables as well as determining goodness of fit. Finally, correlation coefficients were calculated to determine relationship between two variables.

Research Questions

The main objectives of this study were to determine if relationships exist between the following concepts:

- Employee perceptions of trust for two levels of leadership,
    - Laboratory supervisor and principal investigator
- Employee perceptions of safety climate,
- Interactions between employee trust in the principal investigator and laboratory supervisor with employee perceptions of safety climate in the research laboratory environment.

To this end, the following research questions were explored:

1. What is the relationship between the level of employee trust in the principal investigator and the laboratory supervisor?
2. What is the relationship between the level of employee ratings of safety climate in the principal investigator and the laboratory supervisor?
3. What is the relationship between the level of employee trust in the principal investigator and the laboratory supervisor with the level of safety climate?

Results

Participants in this study consisted of laboratory workers from Iowa State University research laboratories using hazardous and non-hazardous materials including radiological, biological and chemical agents. Of the 509 email invitations, 142 responded. Of these 142 respondents, 105 provided usable data, for a response rate of 21%. The respondents are representatives from 23 departments, 58 principal investigators, and 96 university research laboratories. Looking at the type of laboratory hazard associated with the respondents, 31 radiological, 32 biological, and 42 chemical laboratories are represented. Thirty six of the 105 respondents responded to the parts of the questionnaire relating to the laboratory supervisor. Possible reasons for this outcome is 1) the respondent's principal investigator is the laboratory supervisor, 2) the respondent is the laboratory supervisor or 3) the respondent did not want to answer questions regarding the laboratory supervisor. Demographic characteristics of the respondents are shown in Table 1.

Table 1

General Respondent Demographic Data (n=105)

Gender	Male	51	49%
	Female	54	51%
Age	18-20	6	6%
	21-30	69	66%
	31-40	13	12%
	41-50	11	10%
	51-60	4	4%
	Over 61	2	2%
Status	Student	65	62%
	Faculty	1	1%
	Staff	39	37%
Education	Bachelor's	49	47%
	Master's	26	25%
	Doctoral	20	19%
	No Degree	10	10%

Using SAS 9.4 statistical software, simple statistical values for the trust and safety climate variables including means, standard deviations, and correlations were determined. The mean and standard deviation data is detailed in Table 2.

Scale reliability was tested by performing Cronbach's alpha calculations for the trust and safety climate variables. The reliability of the principal investigator and laboratory supervisor trust variables were 0.90 and 0.92, respectively, while the safety climate variables showed reliability scores of 0.88 and 0.84. These scores demonstrate better than satisfactory internal consistency as they are above the standard guideline of 0.80 (Connelly, 2011; Bryman and Cramer, 2009).

Table 2

Means and Standard Deviations for Trust and Safety Climate

Variable	*n*	Mean	Standard Deviation	Minimum	Maximum
Principal Investigator Safety Climate	105	4.23	0.63	2.31	5.00
Principal Investigator Trust	105	4.41	0.62	2.40	5.00
Laboratory Supervisor Safety Climate	36	4.18	0.95	1.56	5.00
Laboratory Supervisor Trust	36	4.23	0.93	1.50	5.00

Research question 1—what is the relationship between the level of employee trust in the Principal Investigator and Laboratory Supervisor?—can be answered by plotting the mean values for the employee perceptions of trust in the principal investigator and the corresponding trust data for the laboratory supervisor. Fitting linear regression model to the data helps determine the direction and significance of the relationship between the dependent and independent variables. This relationship is demonstrated by a scatterplot of the data in Figure 1.The slope and intercept for the regression equation are 1.13 and 0.71, respectively. Since the slope is positive, the overall relationship is positive and a coefficient of determination of 0.55 means the relationship is significant.

Research question 2—what is the relationship between the level of employee ratings of safety climate in the principal investigator and the laboratory supervisor?—can be answered by plotting the mean values for the employee perceptions of safety climate in the principal investigator compared to the corresponding safety climate data for the laboratory supervisor.

Fitting linear regression model to the data helps determine the direction and significance of the relationship between the dependent and independent variables. This relationship is demonstrated by a scatterplot of the data in Figure 2. The slope and intercept for the regression equation are 1.34 and 1.52, respectively. Since, the slope is positive the overall relationship is positive and a coefficient of determination of 0.77 means the relationship is significant.

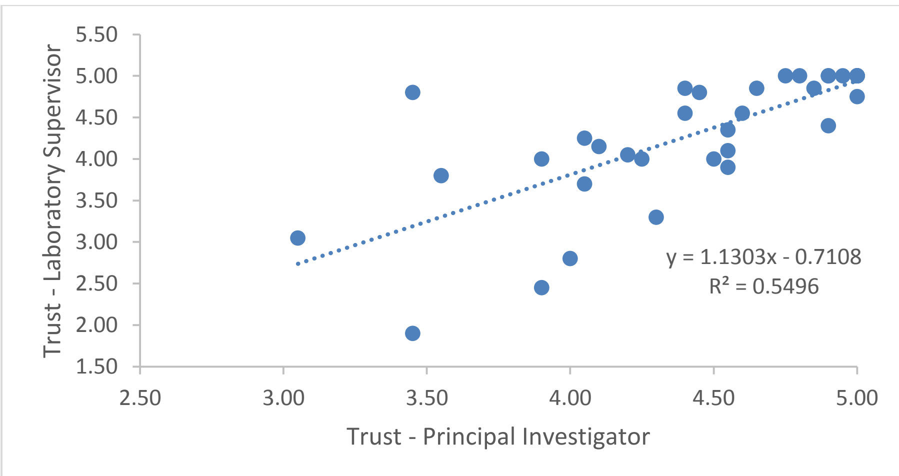

Figure 1. Scatterplot of Principal Investigator and Laboratory Supervisor Trust (*n*=36)

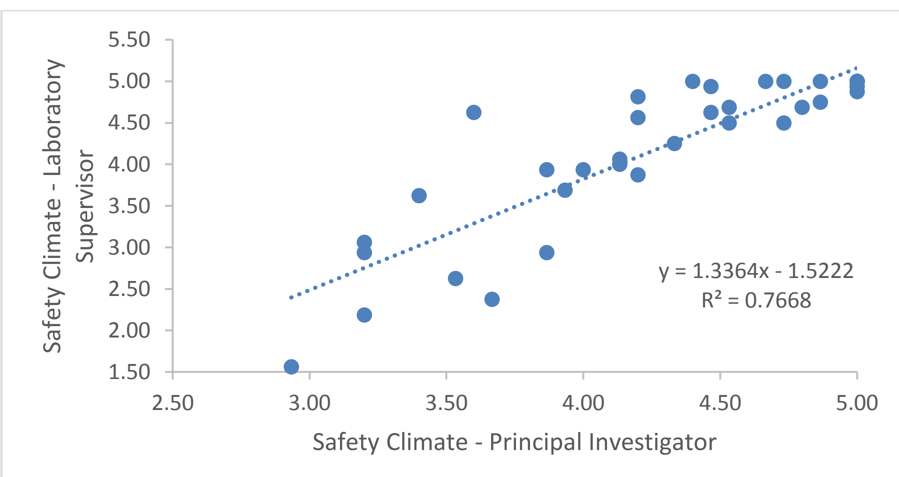

Figure 2. Scatterplot of Principal Investigator and Laboratory Supervisor Safety Climate (*n*=36)

Research question 3—what is the relationship between the level of employee trust in the principal investigator and the laboratory supervisor with the level of safety climate? —can be answered by plotting the four combination of the mean values for the employee perceptions of trust and safety climate for both the principal investigator and laboratory supervisor. Fitting linear regression model to the data helps determine the direction and significance of the relationship between the dependent and independent variables. The relationships demonstrated by scatterplots of the data in Figure 3 through Figure 6 show significant, positive relationships for the different combinations of the trust and safety climate variables.

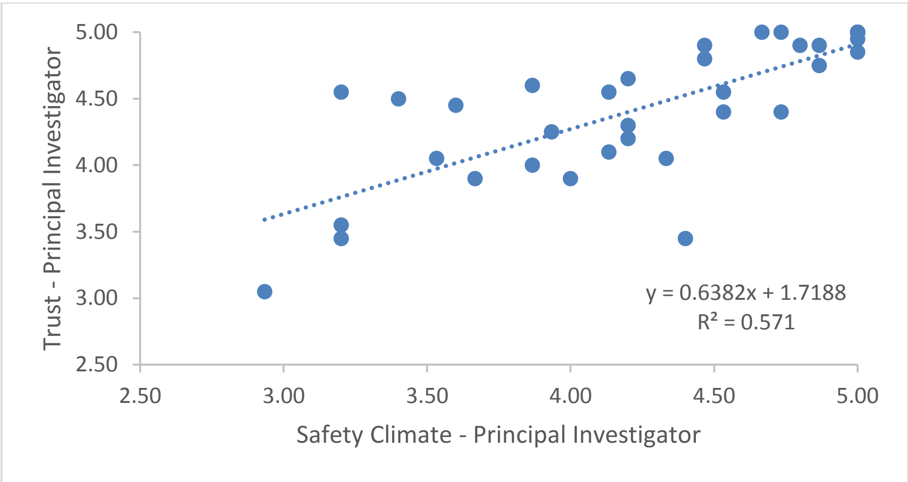

Figure 3. Scatterplot of Principal Investigator Trust and Safety Climate (*n*=36)

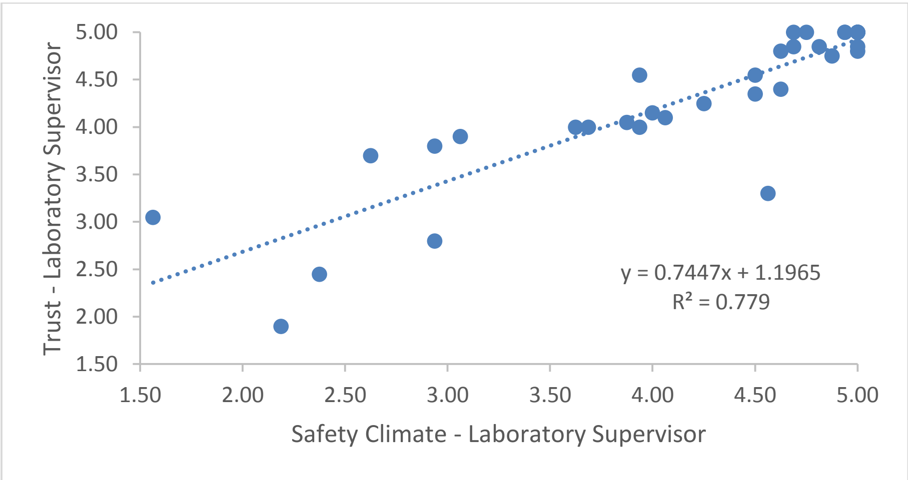

Figure 4. Scatterplot of Laboratory Supervisor Trust and Safety Climate (*n*=36)

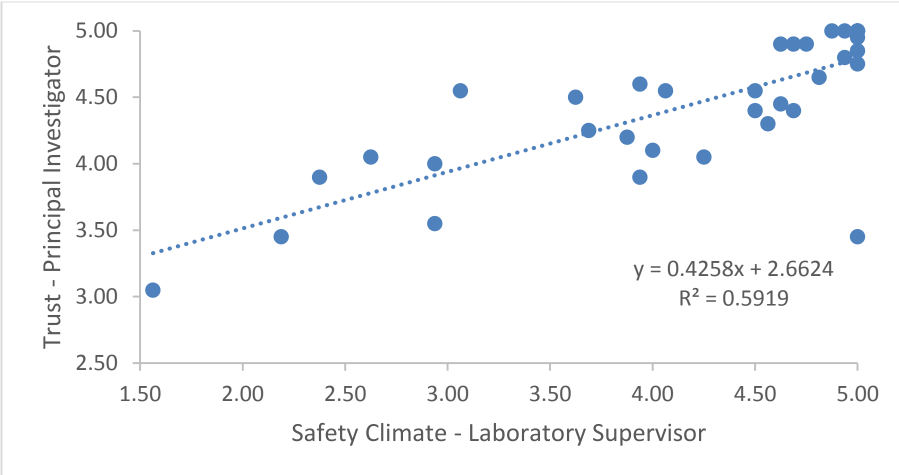

Figure 5. Scatterplot of Principal Investigator and Laboratory Supervisor Safety Climate Trust (*n*=36)

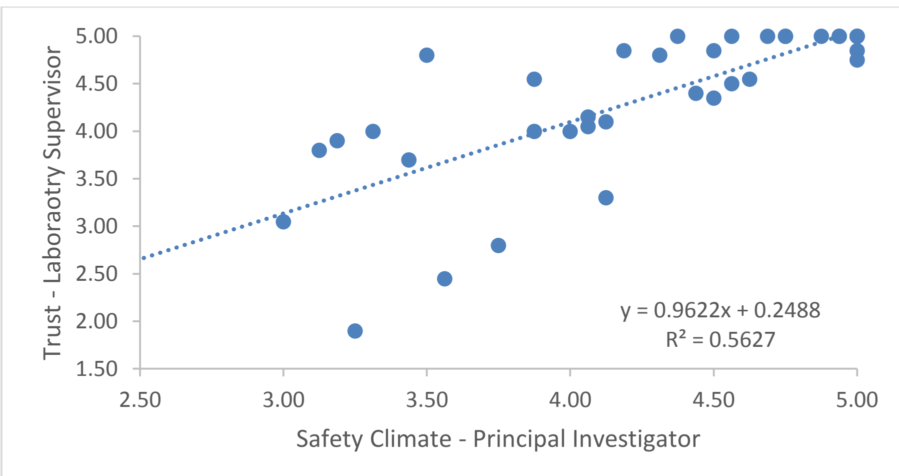

Figure 6. Scatterplot of Laboratory Supervisor Trust and Principal Investigator Safety Climate (*n*=36)

Correlation coefficients describe the amount of linear dependence variables have with each other. Table 3 details the positive correlations between the relationships of trust and safety climate for both management levels within the university research laboratory environment. There are strong positive relationships between the worker perceptions of principal investigator trust and principal investigator safety climate variables as well as the laboratory supervisor trust and laboratory supervisor safety climate variables. Also, there are strong positive relationships between principal investigator and laboratory supervisor trust and principal investigator and laboratory supervisor safety climate.

Table 3

Correlation Coefficients for the Trust and Safety Climate Variables

Variable	PI T	PI SC	LS T	LS SC
Principal Investigator Trust (PI T)	1.000			
Principal Investigator Safety Climate (PI SC)	0.765*	1.000		
Laboratory Supervisor Trust (LS T)	0.565*	0.599*	1.000	
Laboratory Supervisor Safety Climate (LS SC)	0.765*	0.861*	0.777*	1.000

* indicates significance at $p<0.05$; $n=36$;

Table 4

Relationships of Employee Perceptions of Trust and Safety Climate

Variable Tested	Standardized Regression Coefficients (*r*)	Standard Error of Regression Coefficient	*F*-value	*t*-value
Principal Investigator Trust and Laboratory Supervisor Trust	0.320	0.080	15.94*	3.99*
Principal Investigator Safety Climate and Laboratory Supervisor Safety Climate	0.566	0.057	97.14*	9.86*
Principal Investigator Trust and Principal Investigator Safety Climate	0.747	0.061	149.16 *	12.21*
Laboratory Supervisor Trust and Laboratory Supervisor Safety Climate	0.794	0.109	53.30*	7.30*
Principal Investigator Trust and Laboratory Supervisor Safety Climate	0.353	0.197	46.78*	6.84*
Laboratory Supervisor Trust and Principal Investigator Safety Climate	0.393	0.0903	17.97*	4.24*

* indicates significance at $p\leq0.05$; $n=36$;

Finally, bivariate linear regression was used on the variable responses to determine if the principal investigator safety climate explains a significant amount of variance in the principal investigator trust. Likewise, similar analysis was performed for the laboratory supervisor trust and safety climate variables. Standardized regression coefficients (*r*) were used along with F-values to calculate the proportion of variance in trust levels explained by the safety climate responses. The standard error of the regression coefficient determines how much the regression coefficient could differ between responses (Bryman and Cramer, 2009). These summary data from these regression models shown in Table 4 demonstrate that significant positive relationships exist between trust and safety climate at both levels of laboratory management, even with the low sample size.

Discussion

This study investigated the university research laboratory worker perceptions of trust in their principal investigators and laboratory supervisors. The study aimed to show a positive and significant relationship between employee perceptions of trust and safety climate. Other studies have demonstrated that relationships exist between trust and safety climate (Mosher, 2011, 2013; Mosher, Keren, Freeman & Hurburgh, 2013). Many studies have focused on employees' relationship with different levels of leadership in various industries (Mosher, 2011; Burt & Stevenson, 2009; Clarke, 2006; Zohar, 1980). Studies researching perceptions of trust and the impact on safety climate in the university research laboratory environment have not been conducted. Although Gutiérrez et al. (2013) concluded that improvements in safety climate may come through stronger relationships between the supervisors and employees, her work did not specify relational attributes that should be studied.

This study has demonstrated that the level of an employee trust in their principal investigator impacts the organizational safety climate because there exists strong positive, significant relationships between organizational level of trust and organizational safety climate. Meaning, the more trust the laboratory worker has in his/her principal investigator the greater the improvement in the safety climate. Similarly, the greater the level of trust the laboratory worker has with his/her laboratory supervisor, the greater the improvement in the safety climate. These findings support the many studies accomplished regarding these relationships (Mosher, 2011; Kath et al., 2010; Mayer & Gavin, 2005).

Finally, the study has shown that a strong positive relationship exists between organizational trust and laboratory safety climate as well as laboratory trust and organizational safety climate. The perceptions by the laboratory worker of the principal investigator for both trust and safety climate had higher means and lower standard deviations than the same statistics for the perceptions associated with the laboratory supervisor. This aligns with other studies which have concluded that there is, generally, higher trust in the organizational level of management than the direct supervisor (Luria, 2010; Mayer & Gavin, 2005; Dirks & Ferrin, 2002).

Limitations

Most universities have broad and diverse levels of organizational leadership and communications which make this study a challenge to achieve. This university has database systems for tracking research activities including projects, funding, staffing, inspection, incident, and non-compliance data. Generally, these systems are unconnected and inaccessible to the general public. This fact is a limitation for this study since there is no comprehensive list of laboratory workers, their laboratories, their principal investigator, or their laboratory supervisor. The environmental health and safety department has a laboratory safety database that houses information on types of research performed in a given laboratory and the principal investigator. For this study, the principal investigators were contacted by email and asked to provide a list of the email addresses of their laboratory workers. Approximately 50% of contacted principal investigators agreed to support this research leading to the 509 laboratory workers contacted to participate in the online survey.

Only 142 of the possible 509 people attempted to complete the survey even after three separate reminder emails. Of the 142 participants, 105 completed all the pertinent questions on the survey. Of the 105 participants, 36 completed the questions that pertained to their laboratory supervisor. Possible reasons for the low sample size is that a significant majority of research laboratories do not have a designated laboratory supervisor, some respondents were laboratory supervisors, or respondents did not want to answer questions about the laboratory supervisor. This low sample size may help explain the higher standard deviation from the mean for laboratory supervisor trust and safety climate data.

Another potential impact on response rates in this environment is the nature of the student workers with competing priorities. More than 70% of the respondents were graduate and undergraduate students that must balance university coursework and research activities with deadlines in both. In addition, they also must deal with university distractions and timeframes. The selection of the appropriate time in the semester to administer this survey could have impacted the results. The survey went out to workers in late spring, shortly before the end of the semester, a time filled with class assignments, increased research preparation and graduation.

Studying the optimal timing for conducting this research could improve the overall response rates.

Conclusions

The main objectives of this study were to evaluate employee perceptions of trust for two levels of leadership and safety climate as well as determine interactions between employee perceptions of trust with employee perceptions of safety climate in the research laboratory environment. Based on the findings of this study, the following conclusions were drawn:

1. There is a significant positive relationship between the level of employee trust in the principal investigator and the laboratory supervisor.
2. There is a significant positive relationship between the level of employee ratings of safety climate for the principal investigator and the laboratory supervisor.
3. There are significant positive relationships between the level of employee trust in the principal investigator and the laboratory supervisor with the level of safety climate.

The study of the means and standard deviation data suggests that there seems to be stronger trust and safety climate in the principal investigator than in the laboratory supervisor. Also, the study has shown that a significant positive relationship exists between organizational trust and laboratory safety climate as well as laboratory trust and organizational safety climate. The perceptions associated with the principal investigator for both trust and safety climate had higher means and lower standard deviations than the same statistics for the perceptions associated with the laboratory supervisor. This aligns with other studies which have concluded that there is, generally, higher trust in the organizational level of management than in the direct supervisor (Luria, 2010; Mayer & Gavin, 2005; Dirks & Ferrin, 2002).

Finally, this study and possible interventions become more important knowing that previous research has determined that there is a decline in trust in our society (Kramer & Pittinsky, 2009; Kramer & Cook, 2004; Kramer, 1999; Nye, Zelikow, & King, 1997). Determining ways to improve employee trust in leadership is key to a safer workplace environment.

Recommendations for Future Research

Based on the findings of this research the following are recommendations for future research:

- Study employee perceptions of trust and safety climate at other university research laboratories.
- Study possible interventions and their impact on trust and safety climate at the principal investigator and laboratory supervisor levels—for example, develop seminars and workshops for laboratory leadership emphasizing the importance of trust factors such as consistency and credibility as well as safe work practices and their impact on research laboratory workers.
- Develop and study safety policy changes and their impact on trust and safety climate in university research laboratories.

Recommendations for Safety Practices and Policy Improvements

The following are recommendations for possible safety practices and policy improvements that can be implemented at university research laboratories:

- Principal investigator needs to ensure support of the laboratory supervisor's action for implementing safer work practices in the laboratory.

- Laboratory management should work with safety resources like the institution's environmental health and safety department to formulate possible improvements to laboratory policies and work practices.
- Laboratory supervisor should develop and implement safer work practices for their laboratory through an evaluation of workplace hazards and laboratory protocols.
- Laboratory management should obtain feedback from the workers on post implementation activities. For example, a directed survey could be used on a periodic basis to measure worker success of training relative to new work practices.
- Laboratory management should recognize, promote, and reward safe work practices.
- Environmental health and safety departments should continue to actively work with laboratory management as well as institutional leadership to develop, implement, and promote safe work practices and laboratory policies like regular interactions, seminars, and research methods safety evaluation.

References

Benderly, B.L., (2014). The Landmark Patrick Harran Case Ends Inconclusively. *Science Careers from Science*. Retrieved February 14, 2015 from http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2014_07_09/caredit.a1400176

Beus, J.M., Bergman, M.E., & Payne, S.C. (2010). The influence of organizational tenure on safety climate strength: A first look. *Accident Analysis and Prevention*, 42(1), 1431-1437.

Bryman, A., and D. Cramer. 2009. Quantitative Data Analysis with SPSS 14, 15, and 16. *Routledge, Taylor and Francis Group*, New York, N.Y.

Burt, C.D.B., Stevenson, R.J. (2009). The relationship between recruitment processes, familiarity, trust, perceived risk and safety, *Journal of Safety Research*, 40(5), 365-369, doi:10.1016/j.jsr.2009.08.002.

Christensen, K. (2012, January 21). Report faults professor, UCLA in death of lab assistant. *Los Angeles Times*. Retrieved from http://articles.latimes.com/2012/jan/21/local/la-me-ucla-lab-20120121.

Clarke, S. (2006). Safety climate in an automobile manufacturing plant: The effects of work environment, job communication and safety attitudes on accidents and unsafe behavior. *Personnel Review*, 35(4), 413-430.

Connelly, L.M. (2011) Cronbach's alpha. *Journal of the Academy of Medical-Surgical Nurses*, 20(1), 45.

Das, A., Pagell, M., Behm, M., & Veltri, A. (2008). Toward a theory of the linkages between safety and quality. *Journal of Operations Management*, 26(4), 521-535.

Dirks, K.T. & Ferrin, D.L. (2002). Trust in leadership: Meta-analytic findings and implications for research and practice. *Journal of Applied Psychology*, 87(4), 611-628.

Gutiérrez, J.M. (2011). A multi-site pilot test study to measure safety climate in te university work setting. *Unpublished doctoral dissertation*, University of Texas, School of Public Health, Houston, Texas.

Gutiérrez, J.M., Emery, R.J., Whitehead, L.W., & Felknor, S.A. (2013). A means for measuring safety climate in the university work setting. Jo*urnal of Chemical Health & Safety*, 658, 1-10. doi:10.1016/j.jchas.2013.07.001.

Hardin, R. (1996). Trustworthiness. *Ethics*, 107, 26-42.Hofmann, D.A., 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), 286–296.

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

Kath, L.M., Magley, V.J., & Marmet, M. (2010). The role of organizational trust in safety climate's influence on organizational outcomes. *Accident Analysis and Prevention*, 42(1), 2010.

Kernsley, J. (22 January 2009). Researcher Dies After Lab Fire. *Chemical & Engineering News*, Latest News. Retrieved from http://cen.acs.org/articles/87/web/2009/01/Researcher-Dies-Lab-Fire.html

Kines, P., Andersen, L. P. S., Spangenberg, S., Mikkelsen, K. L., Dyreborg, J., and Zohar, D. (2010). Improving construction site safety through leader-based verbal safety communication, *Journal of Safety Research*, 41, 399-406.

Kramer, R.M. & Pittinsky, T.L. (Eds.). (2009). *Restoring Trust in Organizations and Leaders: Enduring Challenges and Emerging Answers.* Oxford University Press. doi:10.1093/acprof:oso/9780199756087.001.0001

Kramer, R.M. & Cook, K.S. (Eds.). (2004). Trust and distrust in organizations: Dilemmas and approaches. *Russell Sage Foundation*: New York.

Kramer, R.M. (1999). Trust and Distrust in Organizations: Emerging Perspectives, Enduring Questions, *Annual Review Psychology*, 50, 569-598.

Lacey, J., Williams, S.P., and Rizzo, M. (2014). Superior Court of the State of California for the County of Los Angeles, Deferred Prosecution Agreement, *Case No. BA 392069*.

Retrieved from https://www.documentcloud.org/documents/1202952-2014-06-20-harran-settlemetn-agreement-from-da.html.

Lafferty, C. L. (2003). *Organizational trust in hospital nursing staffs and its relationship to three performance indicators of organizational effectiveness* (Doctoral dissertation, George Washington University).

Levin, S.L. (1999). Development of an Instrument to Measure Organizational Trust. *Unpublished doctoral dissertation, The George Washington University*, Washington, D.C.

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

Luria, G. (2008). Climate strength – How leaders form consensus. *The Leadership Quarterly*, 19, 42-53.

Luria, G., Zohar, D. and Erev, I. (2008). The effect of workers' visibility on effectiveness of intervention programs: Supervisory-based safety interventions, *Journal of Safety Research*, 39, 273-280. doi: 10.1016/j.jsr.2007.12.003

Mayer, R.C. & Gavin, M.B. (2005). Trust in management and performance: Who minds the shop while the employees watch the boss? *Academy of Management Journal*, 48(5), 874-888.

Mayer, R.C., Davis, J.H. & Schoorman, F.D. (1995). An integrative model of organizational trust. *Academy of Management Review*, 20(3), 709-734.

Milligan, P. K. (2003). *The impact of trust in leadership on officer commitment and intention to leave military service in the US Air Force*. unpublished doctoral dissertation, Capella University, Minneapolis, MN.

Mosher, G. A., Keren, N., Freeman, S. A., & Hurburgh Jr, C. R. (2014). Development of a safety decision-making scenario to measure worker safety in agriculture. *Journal of Agricultural Safety and Health*, 20(21), 91.

Mosher, G. A., Keren, N., Freeman, S. A. & Hurburgh, C. R. (2013). Employee Trust and Its Influence on Quality Climate at Two Administrative Levels, *Journal of Technology, Management, and Applied Engineering*, 29(2), 2-12.

Mosher, G.A. (2013). Trust, Safety, and Employee Decision-Making: A Review of Research and Discussion of Future Directions, J*ournal of Technology, Management, and Applied Engineering*, 29(1), 2-11.

Mosher, G.A. (2011). *Measurement and analysis of the relationship between employee perceptions and safety and quality decision-making in the country grain elevator*. *UMI Dissertations Publishing*, Doctoral dissertation, 3458304. Iowa State University, Ames, IA.

Nature Editorial Panel, (2011). "Accidents in Waiting." *Nature* 472.7343: 259. Retrieved from http://www.nature.com/nature/journal/v472/n7343/full/472259a.html.

Shockley-Zalabak, P., Ellis, K., & Winograd, G. (2000). Organizational trust: What it means, why it matters, *Organization Development Journal*, 18, 35-48.

Thompson, R.C., Hilton, T.F., Wilt, L.A. (1998). Where the safety rubber meets the shop floor: A confirmatory model of management influence on workplace safety. *Journal of Safety Research*, 29(1), 15-24.

Torrice, M. (2013). Patrick Harran To Face Felony Trial On Labor Code Violations. *Chemical & Engineering News*, 91(18), 9. Retrieved from http://cen.acs.org/articles/91/i18/Patrick-Harran-Face-Felony-Trial.html.

U.S. Chemical Safety and Hazard Investigation Board (CSB). (2011). *Case Study: Texas Tech University Lab Explosion,* No. 2010-05-I-TX; Retrieved from http://www.csb.gov/assets/1/19/CSB_Study_TTU_.pdf

Whitener, E.M., Brodt, S.E., Korsgaard, M.A., & 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., Lui, C.W., & 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.

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

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

Zohar, D. (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. (2002). Modifying supervisory practices to improve subunit safety: A leadership-based intervention model. *Journal of Applied Psychology,* 87(1), 156-163.

Zohar, D. (2000). A group-level model of safety climate: Testing the effect of group climate on micro-accidents in manufacturing jobs. *Journal of Applied Psychology*, 85(4), 587-596.

Zohar, D. (1980). Safety climate in industrial organizations: Theoretical and applied implications. *Journal of Applied Psychology*, 65(1), 96-102.

Zohar, D. & Erev, I. (2007). On the difficulty of promoting workers' safety behavior. Overcoming the underweighting of routine tasks. *International Journal of Risk Assessment and Management*, 7(2), 122-136.

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

CHAPTER 3.
IMPACT OF EMPLOYEES' PERCEPTIONS OF TRUST AND SAFETY CLIMATE ON INCIDENTS AND NON-COMPLIANCE EVENTS IN THE UNIVERSITY RESEARCH LABORATORY ENVIRONMENT

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Abstract

Research laboratories from universities to federal facilities have made the headlines nationally, but not for societal improvements. Media and regulatory agencies have been investigating safety practices in these facilities due to major incidents and significant safety violations. Employee perceptions of trust in the leadership and safety climate can be negatively impacted when competing priorities stymie safety practices leading to incidents, injuries and non-compliance. This study examines the relationship between perceptions of trust and safety climate including impacts on incident and non-compliance rates. Laboratory workers from 480 laboratories at a large Midwestern land grant research university were invited to participate in this study through an electronic questionnaire on employee perceptions of trust and safety climate. Statistical analyses were used to determine the relationships between laboratory worker perceptions of trust and safety climate, incident rates, and safety non-compliance events in the research laboratory. This study suggests that university leadership must improve their understanding regarding factors impacting the laboratory if they want to promote a safe working environment for their employees.

Introduction

The university research laboratory leadership and laboratory workers' actions are continually influenced by organizational beliefs, values, and scientific disciplines as well as other competing priorities that include cutting edge research, publishing novel research findings, seeking promotion and tenure, and competitive grant funds (Lodahl, 1972; Kuhn, 1970). These influences make for a conundrum in the research environment. Many times safety and safety practices in university research laboratories are forgotten or ignored by the researcher, laboratory supervisor, and employee (U.S. Chemical Safety and Hazard Investigation Board [CSB], 2011).

Forgotten safety priorities and unsafe work practices can lead to unfavorable incidents and non-compliance with safety guidance in research laboratories. This fact was evident in the events of December 29, 2008 on the University of California, Los Angeles (UCLA) campus and January 7, 2010 on the Texas Tech University campus. Sheharbano (Sheri) Sangji, a 23-year-old chemistry research assistant at UCLA was working with a pyrophoric material that spontaneously combusted igniting her clothes and severely burning her body leading to her death 18 days later (Kernsley, 2009). On January 7, 2010, Preston Brown, a graduate student in the Chemistry and Biochemistry Department at Texas Tech University, lost three fingers on one hand, had burns on his hands and face, and injured one eye when a highly energetic chemical he was working with detonated (U.S. Chemical Safety and Hazard Investigation Board [CSB], 2011). These two incidents are independent events, but many more of these events in university research laboratories are documented both in the United States and around the world. Wu, Lui, & Lu, (2007) detailed many incidents in Taiwanese university research laboratories. Wu et al. (2007) discussed laboratory safety incidents including safety deficiencies or non-compliance events as a growing problem in research laboratories. In the United States, the Nature Editorial

Panel (2011) article "Accidents in waiting", details UCLA and Texas Tech University incidents as well as other recent high profile incidents in the university research environment. The article had a warning for "universities and researchers who feel that there are no lessons to be learned from such accidents [that they] are a danger to themselves and others" (para. 9).

The United States Chemical Safety and Hazard Investigation Board (CSB) for the first time in its history, took the lead on the biggest investigation into research laboratory safety (Johnson & Kemsley, 2011). Prior to this action, CSB only investigated safety incidents in industrial environments. The State of California Department of Labor Relations Division of Occupational Safety and Health's criminal investigation and report (Christensen, 2012) led to the indictment of Patrick Harran, the UCLA researcher and chemistry professor responsible for Sheri Sangji's research laboratory by the Los Angeles District Attorney. Dr. Harran was tried on four felony charges for violating workplace safety standards leading to the death of his research assistant (Torrice, 2013).

Six years after Sheri Sangji's death, Dr. Harran entered into a plea agreement with the Los Angeles District Attorney on June 20, 2014. Dr. Harran acknowledged and accepted responsibility for the laboratory conditions, but did not plead guilty to the felony charges (Benderly, 2014; Torrice & Kemsley, 2014; Lacey, Williams, & Rizzo, 2014). Dr. Harran's agreement, in part, requires him to perform approximately 1600 hours of community service, including the development and teaching of a preparatory chemistry class for South Central Scholars, a volunteer organization working with highly motivated, disadvantaged, high school students for five years as well as payment of a $10,000 to the Grossman Burn Center, where Sheri Sangji died (Benderly, 2014; Lacey, Williams, & Rizzo, 2014). Even though this agreement may have fallen short of convicting Dr. Harran for the death of Ms. Sangji, it has changed the conversation in the academic communities around the country (Benderly, 2014).

Five years after the Texas Tech University laboratory safety incident that maimed Preston Brown, there was another explosion in the Texas Tech Chemistry Building causing lacerations and abrasions to four individuals in the vicinity (Ursch, 2015). This incident was believed to have been caused by chemical waste products in the laboratory (Cook, 2015). The incident demonstrated that hazards exist in research laboratories even in facilities where safety issues have garnered national attention.

Safety Incidents

Workplace safety incidents have been studied in many industries for a long time, but university research laboratories have not been the subject of intentional safety research (Gutiérrez, Emery, Whitehead, & Felknor, 2013). Employee perceptions have been recognized as having an important impact on the workplace safety and safety decision-making (Mosher, 2011, Das et al., 2008, Zohar & Luria, 2005). Studies have shown positive relationships between employees' trust of their organizational leadership and safety climate (Mosher, 2013; Mosher, Keren, Freeman & Hurburgh, 2013; Mosher, 2011). Previous studies focused on employees' relationship with different levels of leadership in various industries covering automobile manufacturers, agricultural businesses, aviation, chemical, and shipping (Mosher, 2011; Burt & Stevenson, 2009; Clarke, 2006; Zohar, 1980). Some of these studies have also investigated the impact of these perceptions on incident rates, on changing a supervisor perceptions and knowledge of safety policies and practices, and on providing tools for monitoring and rewarding safety performance resulting in a decrease in incident and non-compliance rates within the organization. (Zohar, 2002; Kath Magley & Marmet, 2010).

Non-compliance

Non-compliance (e.g., safety violation) with applicable local, state and federal regulatory requirements is addressed in the literature as it relates to employees' perceptions of trust and the organizational safety climate (Mayer & Gavin, 2005; Davis, Schoorman, Mayer, & Tan, 2000). Non-compliance happens when organizations or individuals whether willfully or accidently fail to follow prescribed actions or procedures (Davis et al., 2000). Depending on the regulatory agency, non-compliance can range from not completing required training to not following standard operating procedures or protocols. In the case of the UCLA and Texas Tech University incidents, the actions of the graduate students were in violation of their university safety training as well as accepted safe laboratory practices spelled out in the reference book, *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals* (National Research Council, 1995).

Trust

Trust is defined as a willingness to rely on someone to do something for you that you cannot manage alone, and a willingness to accept risk associated with that ability to let the other person help (Mosher, 2013; Dirks & Ferrin, 2002; Kramer, 1999; Mayer, Davis, & Schoorman, 1995; Shockley-Zalabak, Ellis, & Wingrad, 2000; Whitener, Brodt, Korsgaard, & Werner, 1998). Various constructs define trust. Mayer et al. (1995) define trust as cooperation, confidence, and predictability. Subsequent research has demonstrated that 1) consistency, 2) credibility, 3), competence and 4) concern or benevolence are the four main constructs of trust (Mosher, 2013; Shockley-Zalabak et al., 2000; Whitener et al., 1998). In her research, Mosher (2011) confirmed consistency and credibility as main factors explaining the concept of trust. However, it is important to remember that trust is more than constructs.

Trust requires a relationship between at least two people; the trustor and the trustee (Mayer et al., 1995). It is critical for leadership and management to demonstrate trustworthiness to set an example for their employees and gain their trust (Whitener et al., 1998; Hardin, 1996). Organizations that support and encourage management to develop trusting relationships and reward employees for trusting often observe more effective organizations (Whitener et al., 1998). There are differences in the employee perceptions of trust and safety climate in relation to the direct supervisor (e.g., laboratory supervisor) and organizational management (e.g., principal investigator)(Mosher, 2011; Zohar, 2008; Zohar, 200). Other studies confirm that these relationships will be different from one another (Luria, 2010; Mayer & Gavin, 2005; Dirks & Ferrin, 2002) and lead to differing work outcomes (Dirks & Ferrin, 2002). This study and possible interventions become more important in light of the fact that previous researchers have documented the fact that there is a decline in trust in our society as well as universities (Kramer & Pittinsky, 2009; Kramer & Cook, 2004; Kramer, 1999; Nye, Zelikow, & King, 1997).

Safety Climate

Safety climate is defined as an organizational instrument that measures employee perceptions of safety compared with other organizational outcomes (Mosher, 2013; Zohar, 2000). Like trust, there is a debate regarding the constructs of safety climate; however, safety climate is defined as “shared perceptions of the organization's practices and policies pertaining to safety” (Kath, Magley, & Marmet, 2010, p.1489). Many tools have been devised to measure and assess safety climate and the impact of management attitudes toward safety (Clarke, 2006; Hofmann & Morgeson, 1999; Zohar, 1980).

Kath et al. (2010) found that there is agreement regarding the importance of employee perceptions of safety climate and of employees’ trust and comfort in participating in safety communication with their supervisor regarding needs and outcomes. Researchers have also studied the impact of human and workplace factors such as organizational tenure, coaching supervisors to include safety in their daily communications with employees, visibility of management and supervisors, and leadership (Beus, Bergman & Payne, 2010; Kines, Andersen, Spangenberg, Mikkelsen, Dyreborg & Zohar, 2010; Luria, Zohar & Erev, 2008; Luria, 2008; Zohar, 2003). Gutiérrez et al. (2013) concluded that improvements in safety climate may come through stronger relationships between the supervisor and employee as well as increased supervisory training.

Trust and Safety Climate

Trust and safety climate have been studied and tested in many industries and certain outcomes have been documented. There is a positive relationship between factors like employee trust of organizational leadership and the leader's encouragement to have a safe workplace (Luria, 2008). Studies also confirm that intermediate management has less of an impact on workers' perceptions and actions than the organizational management (Mosher et al., 2013; Zohar & Luria, 2005; Thompson Hilton & Witt, 1998).

Limited research exists regarding the relationships between employee perceptions of trust in laboratory leadership, safety climate, and incident and non-compliance rates in university research laboratories. The 2012 University of California Center for Laboratory Safety Workshop made no mention of trust relationships in its proceedings; however, they recognized that "specific interactional attributes affect academic research lab safety culture" (Gibson & Wayne, 2013, p. 10). Gutiérrez et al. (2013) commented that research was "absent" in the literature regarding safety climate in the university laboratory research environment. Since safe workplaces depend heavily on the decisions employees make on the job (Mosher et al., 2014;

Keren, Mills, Freeman, & Shelley, 2009; Zohar & Erev, 2007), an increased understanding of the aforementioned factors may provide useful information in the development of specific safety counter measures, best practices for management, or targeted educational interventions.

To date, there has been little research related to employees' perceptions of trust and safety climate within the university research laboratory environment documented in the literature. This study will examine employee perceptions of trust, safety climate, and incident rates and non-compliance events in university research laboratories. Trust and safety climate data was determined through the use of an online survey instruments and compared to existing historical incident and non-compliance data from the university research laboratory environment. Existing trust and safety climate instruments are available to be modified to measure these factors in the research laboratory setting (Mosher et al., 2013; Gutiérrez et al., 2013). Studying relationships between trust in leadership, safety climate, incident rates and non-compliance events in university research laboratories may spur the development of further interventions that could positively impact safety at these quality research facilities.

Research Questions

The main objectives of this study were to evaluate the organizational factors such as trust and safety climate and their relationship to incident rates and non-compliance events within university research laboratories. To this end, the following research questions were explored:

1. What is the relationship between the level of departmental and group trust with the level of departmental incident rates?
2. What is the relationship between the level of departmental and group safety climate with the level of organizational incident rates?

3. What is the relationship between the level of departmental and group trust with the level of departmental and group compliance rate?
4. What is the relationship between the level of departmental and group safety climate with the level of departmental and group compliance rate?

Methodology

Most universities are divided into colleges and services units. The primary focus of the Colleges are academic and research areas of the institution while service units provide them day-to-day facility support. For the purposes of this study, the focus will be on the factors impacting colleges, which are divided into departments, centers and institutes. Departmental structure is further subdivided into research groups led by principal investigators (i.e., researchers), who have laboratory supervisors and laboratory staff working to perform research within assigned laboratory rooms.

Local, state, and federal entities have jurisdiction regarding the definition of safe work policies, procedures, and practices specific to the hazards in the workplace. These entities require registration, certification, training, reporting, and documentation from organizations to prove that they are complying with specified rules, regulations and guidelines. These entities inspect and audit organizations to verify organizational compliance and, based on the findings, may impose corrective actions to mitigate non-compliance. Sometimes, fines may be levied on organizations depending on the severity of non-compliance or the risk to worker and public health and safety.

Generally, over the years, research laboratories have had many minor safety incidents and non-compliance events. However, Gutiérrez et al. (2013) explains that due to the unique nature and pressures associated with a research environment, there is a potential for significant incidents to occur.

The United States Occupational Safety and Health Administration (OSHA) requires a log to be maintained that documents recordable worker injuries and illnesses and then summarized annually in the OSHA 300 Form (Recording and Reporting Occupational Injuries and Illness, 2001). Also, calculated and reported as part of the form is the Days Away, Restricted, or Transferred (DART) rate. For the purposes of this study, incidents are defined as the injury and illness data reported by employees and their supervisors through the University's First Report of Injury (FROI) system, which is a larger set of data including the incidents required to be reported to OSHA (Iowa State University, 2015).

Participants in the study included faculty, staff, and students working in research laboratories at Iowa State University. The study surveyed the laboratory workers, who reported to a specific laboratory supervisor and/or principal investigator. Because there were 1,500 research laboratories with about 500 principal investigators, this study selected participants from laboratories with particular hazards—chemical, biological, and radiological—associated with their research. Radiological laboratories were the limiting group of the three with about 178 active rooms. There were 379 active biological laboratories and 704 active chemical research laboratories. Random sampling of each group ensured that the subgroups like laser, biosafety level 3 (BSL-3) and x-ray laboratories were represented in the data analysis. This sampling protocol was strengthened due to fact that these varied research laboratories had similar safety protocols and safety requirements including training, protocol review, waste management, and inventory controls.

Two validated survey instruments were combined and modified for the research laboratory environment; they were used to measure employee perceptions of trust and safety climate (Mosher, 2011; Levin, 1999). Research by Zohar (2000, 2008) on measuring perceptions of human factors like safety climate and leadership, at two levels of management in the workplace were foundational for the study. Zohar suggested that employees have differing perceptions of the organizational leader and the employee's supervisor due to the types and ways they communicate, interact, and respond to these management groups (Zohar, 2000; Zohar, 2008; Mosher, 2011). In other words, the organizational leader sets the direction for the workplace and the supervisor determines the steps to move the group in that direction (Zohar, 2008).

For this study, the Management Behavior Climate Assessment developed by Levin (1999) and validated by Mosher (2011) was used to measure employee perceptions of trust in their management and their supervisor (i.e., principal investigator and laboratory supervisor). This instrument was tested and validated by Levin (1999) in a number of manufacturing, academic, military, and government environments as part of its' development. Since that time, other researchers had evaluated other industries including nursing, U.S. Air Force, and grain elevator operators (Lafferty, 2000; Milligan, 2003; Mosher, 2011). This instrument consists of 40 questions using a 5-point Likert-type scale (5 = always or almost always; 4 = usually; 3 = occasionally; 2 = seldom; and 1 = rarely or never) as well as demographic data. Minor modifications to the instrument included defining top management as the principal investigator and supervisor as laboratory supervisor. Demographic data was collected such as age, gender, education level, native language, safety training experience, and time in the research laboratory environment. Mosher (2011) performed confirmatory factor analysis on the data confirming consistency and credibility as two main factors explaining the concept of trust.

Regarding the measurement of employee perceptions of safety climate, there are two potential choices for the measurement of employee perceptions of safety climate: the Organization and Group Level Safety Climate (Zohar & Luria, 2005) instrument and the University Safety Climate Questionnaire (Gutiérrez, 2011). The University Safety Climate Questionnaire is based on Wu et al. (2007) safety climate instrument and has a broad focus, studying safety climate in the university workplace setting. The survey was administered at five universities in the United States for comparative analysis. Gutierrez (2011) pointed out that future safety climate surveys should focus on major groups within the university.

Zohar and Luria (2005) developed the Organization and Group Level Safety Climate instrument to determine employee perceptions of safety climate for organizational management and direct supervisor. This instrument has been validated over many industries such as automobile manufacturers, agricultural businesses, aviation, chemical, and shipping (Mosher, 2011; Johnson, 2007). For purposes of this study, the Organization and Group Level Safety Climate instrument was used, since it specifically targets two levels of management within an organization. The Organization and Group Level Safety Climate instrument consisted of 32 questions using a 5-point Likert-type scale (5 = always or almost always; 4 = usually; 3 = occasionally; 2 = seldom; and 1 = rarely or never) as well as demographic data. Minor modifications to the instrument included defining top management as the principal investigator and supervisor as the laboratory supervisor. Based on Wu et al. (2007) study of research laboratories, demographic data was collected such as age, gender, education level, safety training experience, and time in the research laboratory environment.

The instrument administration was a complex process consisting of several major steps—garnering support from the university administration and impacted principal investigators, determining sample laboratories based on hazard classification and risk ranking, and collection of laboratory worker contact information. The university has approximately 1,500 research laboratories with about 500 principal investigators. Laboratories were selected based on associated hazards—chemical, biological, and radiological—and the overall risk ranking.

The risk ranking was based on audit findings for the research laboratory and particular severity levels and frequency of the findings. Findings are based on relevant federal, state and local regulations and guidelines for particular hazards in laboratories. There were approximately 200 radiological laboratories, 400 biological laboratories, and 900 chemical research laboratories within the university. Laboratories were stratified based on hazard type and risk level; 160 laboratories of each hazard type were randomly selected for this study. Principal Investigators for the selected laboratories received an email memorandum from the University Provost and the Assistant Vice President for the Department of Environmental Health and Safety requesting support for this study. Additionally, they received an email requesting potential participant names and email addresses. The potential participants were emailed a link to the electronic trust and safety climate instrument.

Basic statistical analyses (i.e., means and standard deviations) were performed on the survey data from the two questionnaires. The data were analyzed as a whole and then separated into group and departmental level results. Simple linear regression analysis was performed on employee perceptions of trust and safety climate data to determine if there is a significant relationship between them in the university research laboratory environment.

Incident and injury data were requested from the university human resources department. At Iowa State University, workers and their supervisor are required to report any incidents and injuries on campus through the University's First Report of Injury (FROI) system. Data collected includes, type of accident or injury, supervisor, location and department. The data collected were cleaned to eliminate non-research spaces, then summarized in different categories, for example, incident type, location, and department.

Non-compliance data were collected through laboratory safety surveys conducted by the Department of Environmental Health and Safety. The safety survey was a safety audit, including a check list of 86 compliance items such as updated hazardous material inventories and emergency action plans, completed safety training, and capped hazardous materials containers. The data are stored in the department's Laboratory Safety Database to ensure ease of retrieval for inspection by regulatory agencies. The laboratory safety surveys cover a myriad of safety regulatory compliance requirements including written protocols, safety training, chemical, biological, and radiological inventory maintenance, and personal protective equipment availability and use. The data collected were cleaned to eliminate non-research spaces, then summarized in categories such as non-compliance event, location, and department. Incident and non-compliance data was compared to trust and safety climate data through simple linear regression to determine any relationships related to the research questions.

Security of all data was maintained electronically on password protected ISU supported systems. Names of participants and persons identified in incident and non-compliance data were not collected or were deleted through the data cleaning process.

Results

Participants in this study consisted of laboratory workers from Iowa State University research laboratories using hazardous and non-hazardous materials including radiological, biological and chemical agents. Of the 509 email invitations, 142 responded. Of those 142 respondents, 110 provided usable data, for a response rate of 21%. The respondents were representatives from 23 departments, 58 principal investigators and 67 university research laboratories. Looking at the type of laboratory hazard associated with the respondent, 32 were radiological, 34 biological, and 44 chemical. Thirty six of the 110 employees answered the parts of the questionnaire relating to the laboratory supervisor. Table 1 presents demographic data, which includes gender, age, employment status and education. One hundred and five of the 110 respondents provided a complete set of demographic data.

Table 1

General Respondent Demographic Data (n=105)

Gender	Male	51	49%
	Female	54	51%
Age	18-20	6	6%
	21-30	69	66%
	31-40	13	12%
	41-50	11	10%
	51-60	4	4%
	Over 61	2	2%
Status	Student	65	62%
	Faculty	1	1%
	Staff	39	37%
Education	Bachelor's	49	47%
	Master's	26	25%
	Doctoral	20	19%
	No Degree	10	10%

Incident data collected from the University Human Resources department were from January 2012 through June 30, 2014, since there were only 28 reported injury and illness events documented for the research laboratories during this study's data collection period, March 2014 to June 2014. The total number of incidents for all areas of campus including research laboratories were 1,248. One hundred and seventeen incidents were from research laboratories; 47 were in biological, 46 were in chemical, and 24 were in radiological. Laboratory incidents were from 35 different departments on campus. However, the total number of incidents from respondent departments was 87.

Table 2 presents the distribution of the incidents and non-compliance events by respondent departments. From the incident data, one of the 23 departments had 31% of the incidents. Five of the 23 departments, 22% accounted for 69% of all laboratory incidents. The two departments with the highest incident rates included laboratories conducting research using biological materials and chemicals. The department with the highest incident rate, 27 had 14 incidents resulting from punctures or lacerations.

Table 2 also includes the distribution of the non-compliance events by respondent departments. The three departments with the highest number of non-compliance events were from laboratories doing research with biological and chemical hazards. Their total number of events accounted for 40% of all non-compliance. The top five departments for incidents were the same departments that had the highest incident rates.

Table 2

Incidents and Non-Compliance Events by Department

Department	Incidents	% of Incident by Department	Non-compliance Events	% of Non-compliance Events
1	2	2%	140	1%
2	1	1%	193	1%
3	6	7%	2281	12%
4	7	8%	970	5%
5	2	2%	736	4%
6	2	2%	1321	7%
7	0	0%	242	1%
8	0	0%	161	1%
9	7	8%	417	2%
10	10	11%	2990	16%
11	1	1%	722	4%
12	0	0%	159	1%
13	0	0%	594	3%
14	0	0%	524	3%
15	4	5%	809	4%
16	4	5%	990	5%
17	0	0%	1082	6%
18	1	1%	160	1%
19	0	0%	10	0%
20	2	2%	241	1%
21	2	2%	800	4%
22	9	10%	1439	7%
23	27	31%	2255	12%

Table 3 presents the distribution of the incidents and/or injuries by incident type. Punctures and lacerations are the highest incident rate at 47 of the 87 incidents; accounting for 54% of all incidents based on respondent departments. The next two highest incident rates are from 1) chemical inhalation, burns, and exposures, and 2) bumps, bruises and contusions with 14 incidents each. The top three incidents account for 64% of all incidents.

Table 3

Incidents/Injuries by Incident Type

Incident Type	Incidents	% of Incidents by Type
Animal Bites & Injuries	9	8%
Bumps, Bruises, Contusions, etc.	14	12%
Burns	6	5%
Chemical Inhalation, Burn, Exposure	14	12%
Foreign Matters in Eyes, Eye Injury	10	9%
Fractures, Dislocations, Broken Bones	2	2%
Punctures, Lacerations	47	40%
Skin Reactions	4	3%
Slips, trips, falls, contusions	5	4%
Sprains, Strains, Injuries	5	4%
Stress	1	1%

There are 86 different types of non-compliance events in the laboratory safety survey audits and the non-compliance data set has a total of 27,577 non-compliance events. All non-compliance event types are represented in the respondent departments. The total number of non-compliance events from the respondent departments was 19,236 which is 90% of all non-compliance data from the data set. Table 4 is a listing of the top 10 non-compliance event types associated with the respondent data set. The top three non-compliance event types account for 44% of the top 10 types.

With 86 different non-compliance event types, an analysis of individual event types was rigorous, so one of two categories of event types, procedural or physical, were determined and assigned to each non-compliance event type. Procedural non-compliance events included, but was not limited to, chemical, biological and radiological inventory, emergency action plans, safety surveys, and safety training. Physical non-compliance events included, but was not limited to, containers labeled and closed, eyewash and safety shower, satellite accumulation area, and first aid kit.

Table 4

Top10 Non-compliance Event Types

Non-compliance Event Types	Non-compliance events	% of Non-compliance Events
Chemical/Biological/Radiological inventory	2693	16%
Emergency action plan	2612	15%
Safety surveys	2298	13%
Containers labeled and closed	1892	11%
Eyewash and safety shower	1850	11%
Safety training	1849	11%
Signage	1550	9%
Waste satellite accumulation area	897	5%
First aid kit	860	5%
Electric items	837	5%

To analyze the trust and safety climate from the employee perceptions of trust and safety climate for the principal investigator and laboratory supervisor data against incidents and non-compliance events, the principal investigator and laboratory supervisor trust data was averaged as well as the principal investigator and laboratory supervisor safety climate data.

Using SAS 9.4, SPSS and Microsoft Excel statistical software, simple statistical values for the trust and safety climate variables including means, standard deviations, and correlations were determined. Table 5 presents the summary of means and standard deviations for the overall employee trust and safety climate survey data. The sample size of 110 respondents who completed the trust and safety climate survey and completed the demographic data pertaining to laboratory location. For the purposes of this study, missing demographic data such as gender, age, and education are not being evaluated. The results show that the means and standard deviations for employee trust and safety climate are similar. Given the maximum possible value for trust and safety climate was five, the mean values are 87% and 85% of that value, respectively. These values represent the fact that the employee perceptions of trust and safety climate are high in the study's research laboratory environment.

Table 5

Means and Standard Deviations for Trust and Safety Climate (*n*=110)

Variable	Mean	Standard Deviation	Minimum	Maximum
Trust	4.36	0.69	2.15	5.00
Safety Climate	4.26	0.69	2.24	5.00

The scatterplot of the means for the overall employee trust and safety climate survey data is shown in Figure 1 with a positive slope of 0.71 from the regression line and a coefficient of determination of 0.62. As expected, these values demonstrate a strong, positive relationship between employee perceptions of trust in research laboratories and safety climate.

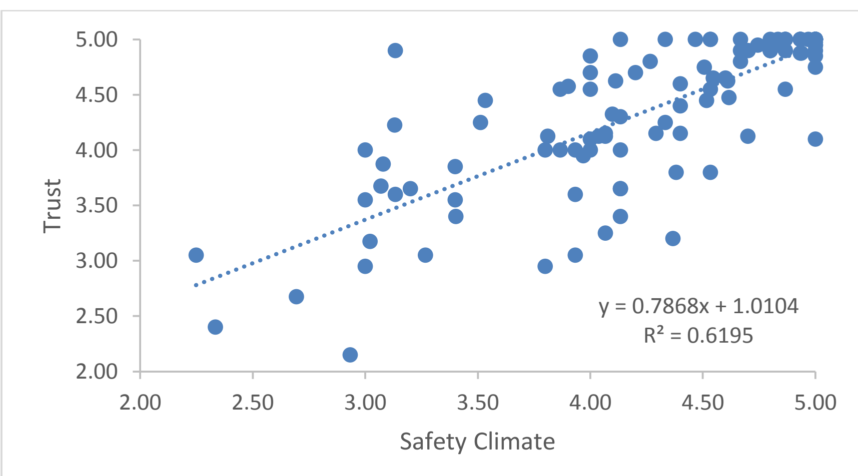

Figure 1. Scatterplot of Respondent Overall Trust and Safety Climate (*n*=110)

Using the PROC Mixed procedure from SAS software package, Table 6 and Table 7 contain the outcomes from the mixed linear models to determine if statistically significant relationships exist. Table 6 contains the impacts of incident rates based on laboratory hazard classifications and departments on employee trust and safety climate.

Table 6

Incident rates based on Laboratory Hazard Classifications and Departments on Trust and Safety Climate

	Effect	Num DF	Den DF	*F* Value	Pr > *F*
Trust	Lab Type Incident Rate	2	107	0.22	0.805
Trust	Department Incident Rate	8	101	4.07	<0.001*
Trust	Organizational Incident Rate	1	108	0.13	0.718
Safety Climate	Lab Type Incident Rate	2	107	0.44	0.648
Safety Climate	Department Incident Rate	8	101	2.47	0.017*
Safety Climate	Organizational Incident Rate	1	108	0.04	0.848
	Department	22	86	2.8	<0.001*
Trust	Organizational Incident Rate	1	86	0.1	0.752
	Laboratory Type	2	106	0.18	0.834
Trust	Organizational Incident Rate	1	106	0.06	0.804
	Department	22	86	2.6	<0.001*
Safety Climate	Organizational Incident Rate	1	86	0.04	0.834
	Laboratory Type	2	106	0.44	0.646
Safety Climate	Organizational Incident Rate	1	106	0.05	0.826

* indicates significance at $p \leq 0.05$

Research question 1—what is the relationship between the level of departmental and group trust with the level of departmental incident rates?—can be answered based on the analysis. There is a significant relationship between department, trust, and incident rate. There is no evidence proving any significant relationships between laboratory type, trust, and incident rates.

Research question 2—what is the relationship between the level of departmental and group safety climate with the level of organizational incident rates?—can be answered based on the analysis. There is a significant relationship between department, safety climate, and incident rate. There is no evidence proving any significant relationships between department, laboratory type, safety climate, and organizational incident rates. Finally, departments have a significant relationship with trust and safety climate.

Table 7 contains the impacts of non-compliance rates based on laboratory hazard classifications and departments on employee trust and safety climate. From the results, there is a significant relationship between safety climate and non-compliance rate, but not with trust and non-compliance rate.

Research question 3—what is the relationship between the level of departmental and group trust with the level of departmental and group compliance rate?—can be answered based on the analysis. There is a significant relationship between laboratory type, trust, and non-compliance rate. There is no evidence proving any significant relationships between department, laboratory type, trust, and non-compliances rates.

Research question 4—what is the relationship between the level of departmental and group safety climate with the level of departmental and group compliance rate —can be answered based on the analysis. There is a significant relationship between laboratory type, safety climate, and procedural non-compliance rate. There is no evidence proving any significant relationships between department, laboratory type, trust, and non-compliances rates.

Table 7

Non-compliance Rates based on Laboratory Hazard Classifications and Departments on Trust and Safety Climate

Variables	Effect	Num DF	Den DF	F Value	Pr > F
Trust	Non-compliance Rate	41	68	1.39	0.1136
Trust	Procedural Non-compliance	38	71	1.53	0.0605
Trust	Physical Non-compliance	26	83	1.44	0.1073
Safety Climate	Non-compliance Rate	41	68	1.71	0.025*
Safety Climate	Procedural Non-compliance	38	71	1.33	0.1467
Safety Climate	Physical Non-compliance	26	83	1.09	0.3706
Trust	Department	13	55	2.8	0.004*
	Non-compliance Rate	32	55	1.34	0.1677
Safety Climate	Department	13	55	1.71	0.0856
	Non-compliance Rate	32	55	1.22	0.2531
Trust	Laboratory Type	2	66	3.78	0.0279*
	Non-compliance Rate	41	66	1.67	0.0305*
Safety Climate	Laboratory Type	2	66	2.34	0.1044
	Non-compliance Rate	41	66	1.86	0.012*
Trust	Department	15	56	2.1	0.0237*
	Procedural Non-compliance	31	56	1.19	0.2838
Safety Climate	Department	15	56	2.52	0.0063*
	Procedural Non-compliance	31	56	1.31	0.1873
Trust	Laboratory Type	2	69	3.11	0.0507
	Procedural Non-compliance	38	69	1.77	0.0194
Safety Climate	Laboratory Type	2	69	4.77	0.0114*
	Procedural Non-compliance	38	69	1.7	0.028*
Trust	Department	15	56	2.1	0.0237*
	Physical Non-compliance	31	56	1.19	0.2838
Safety Climate	Department	15	56	2.52	0.0063*
	Physical Non-compliance	31	56	1.31	0.1873
Trust	Laboratory Type	2	81	0.05	0.9544
	Physical Non-compliance	26	81	1.4	0.1304
Safety Climate	Laboratory Type	2	81	1	0.3715
	Physical Non-compliance	26	81	1.13	0.3264

* indicates significance at $p \leq 0.05$

Procedural non-compliance rates have significance with trust and safety climate when laboratory type is in the model, however, laboratory type does not have significance. Finally, departments have a significant relationship with trust and safety climate.

Discussion

This study investigated employee perceptions of trust and safety climate and their relationships with incident rates and non-compliance events within university research laboratories.

The study also aimed to confirm that employee perceptions of trust have a positive and significant impact on the safety climate. Other studies have demonstrated that relationships exist between trust and safety climate (Mosher, 2013; Mosher, Keren, Freeman & Hurburgh, 2013; Mosher, 2011). Although Gutiérrez et al. (2013) concluded that improvements in safety climate may come through stronger relationships between the supervisors and employees, her work did not specify relational attributes that should be studied. Studies researching perceptions of trust and the impact on safety climate in the university research laboratory environment have not been conducted. Based on the findings of this study, there is a significant positive relationship between employee perceptions of trust and safety climate in university research laboratories.

Developing the statistical methods for evaluating incident and non-compliance events was complex given the low incident rates in the laboratory and the large number of non-compliance event types as well as the low number of laboratories represented by the responses to the employee trust and safety climate survey. There are significant relationships between department, incident rate, trust, and safety climate. There is a significant relationship between laboratory type, non-compliance rate, and trust. Laboratory hazard classifications and procedural non-compliance rates have a significant relationship with employee perceptions of trust and safety climate. Unrelated to the research questions, departments have a significant relationship with trust and safety climate and non-compliance rates have a significant relationship with safety climate, but not with employee trust.

Limitations

Due to the diverse levels of organizational leadership within the university setting, communications and data management provided unique challenges to this study. The first challenge was determining which service units or departments maintain current lists of departments, research laboratories, principal investigators, laboratory supervisors, and workers. It was determined that there is no comprehensive list of laboratory workers, their laboratories, principal investigator, or laboratory supervisor on campus. The environmental health and safety department has the most comprehensive research laboratory environment database housing information that includes types of research performed in a given laboratory, its principal investigators, associated department, and non-compliance data from periodic safety related audits. However, links to the safety training database were unavailable to provide an accurate list of laboratory workers. For this study, the principal investigators were contacted by email and asked to provide a list of the email addresses of their laboratory workers. Approximately 50% of contacted principal investigators agreed to support this research leading to the 509 laboratory workers contacted to participate in the online survey.

Only 142 of the possible 509 people attempted to complete the survey even after three separate reminders. From the 142 participants, 110 completed all the pertinent questions on the survey. Of the 110 participants, 36 participants completed the questions that pertained to their laboratory supervisor. Possible conclusions for the low sample size is that a significant majority of research laboratories do not have a designated laboratory supervisor, some respondents were laboratory supervisors, or respondents did not want to answer questions about the laboratory supervisor.

Within the online survey, respondents were asked to provide their affiliated research laboratories. The survey did not have a drop down menu to select laboratory location choices, so significant data cleaning was required to identify respondent laboratories. Using demographic data and a combination of queries, laboratories were specified for each respondent.

Another potential impact on response rates in this environment is the nature of the student workers with competing priorities. More than 70% of the respondents were graduate and undergraduate students that must balance university coursework and research activities with deadlines in both. In addition, they also must deal with university distractions and timeframes. The selection of the appropriate time in the semester to administer this survey could have impacted the results. The survey went out to employees in late spring, shortly before the end of the semester, a time filled with class assignments, increased research preparation and graduation. Studying the optimal timing for conducting this research could improve the overall response rate.

Even though the response rates seem low, significant positive relationships were found to exist between employee trust, safety climate, departments and procedural non-compliance event types.

Incident data for the respondent research laboratories were rare data. Only three recorded incidents occurred in the respondent research laboratories out of the 117 research laboratory incidents. Incident data was evaluated based on laboratory hazard classification and department; yielding no significant relationships with employee perceptions of trust and safety climate.

Conclusions

The main objectives of this study were to evaluate employee perceptions of trust and safety climate and their relationship to incident rates and non-compliance events within university research laboratories. Based on the findings of this study, the following conclusions were drawn:

1. There is a significant relationship between department, trust, and incident rate. There is no evidence proving any significant relationships between laboratory type, trust, and incident rates.
2. There is a significant relationship between department, safety climate, and incident rate. There is no evidence proving any significant relationships between department, laboratory type, safety climate, and organizational incident rates. Finally, departments have a significant relationship with trust and safety climate.
3. There is a significant relationship between laboratory type, trust, and non-compliance rate. There is no evidence proving any significant relationships between department, trust, and non-compliances rates.
4. There is no evidence proving any significant relationships between department, laboratory type, trust, and non-compliances rates. However, there is a significant relationship between laboratory type, safety climate, and procedural non-compliance rate.

For both incident and non-compliance data, few departments accounted for a majority of incidents and non-compliance events. Specially, two departments doing in research using biological and chemical materials had higher incident and non-compliance rates. Punctures and lacerations events were four times more likely to happen in research laboratories than any other incident type. Six of the 86 non-compliance event types—updating hazardous material inventories and emergency action plans, performing laboratory safety surveys, ensuring that hazardous materials containers are labeled and closed, testing emergency eyewash stations and safety showers periodically, and having current safety training—accounted for 69% of all non-compliance events.

Based on these findings, initial efforts for improving safety in the research laboratory should be focused around the departments with the highest incident and non-compliance rates as well as developing specific interventions for the incident and non-compliance type with the highest rates.

Recommendations for Future Research

Based on the findings of this research the following are recommendations for future research based on the results of this study:

- Study employee perceptions of trust and safety climate at other university research laboratories and their relationships with incidents and non-compliance.
- Study incident and non-compliance rates at other institutions to increase understanding of their impacts on workplace safety.
- Study possible interventions and their impact on trust, safety climate, incident rates, and noncompliance events.
- Develop and study safety policy changes and their impact on trust, safety climate, incident rates, and non-compliance events in university research laboratories.

Recommendations for Safety Practices and Policy Improvements

The following are recommendations for possible safety practices and policy improvements that can be implemented at research universities:

- University, departmental, and laboratory leadership as well as laboratory workers need to support and participate in the university incident notification and investigation procedures as necessary.
- University, departmental, and laboratory leadership as well as laboratory workers need to continue to support and act on non-compliance event findings to ensure a safer workplace.
- Laboratory management should develop and implement safer work practices for their laboratory through an evaluation of workplace hazards, laboratory protocols, and periodic audits of laboratory safety activities and non-compliance event type.
- Laboratory management should obtain feedback from the workers on post incidents or non-compliance events. For example, using regular laboratory meetings for reviewing incidents and non-compliance events for possible safety improvements.
- University, departmental and laboratory management should recognize, promote, and reward safe work practices.
- Environmental health and safety departments should continue to actively work with university, departmental, and laboratory management to develop, implement, and promote safe work practices and laboratory policies like coordinated laboratory safety, compliance audits and post-incident evaluations.

References

Apler, S.J. & Karsh, B. (2009). A systematic review of safety violations in industry. *Accident Analysis and Prevention*, 41(4), 739–754.

Benderly, B.L., (2014). The Landmark Patrick Harran Case Ends Inconclusively. *Science Careers from Science*. Retrieved February 14, 2015 from http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2014_07_09/caredit.a1400176

Beus, J.M., Bergman, M.E., & Payne, S.C. (2010). The influence of organizational tenure on safety climate strength: A first look. *Accident Analysis and Prevention*, 42(1), 1431-1437.

Beus, J.M., Payne, S.C., Bergman, M.E., & Arthur Jr, W. (2010). Safety climate and injuries: an examination of theoretical and empirical relationships. Journal of Applied Psychology, 95(4), 713.

Burt,C.D.B. & Stevenson,R.J. (2009). The relationship between recruitment processes, familiarity, trust, perceived risk and safety, *Journal of Safety Research*, 40(5), 365-369, doi:10.1016/j.jsr.2009.08.002.

Christensen, K. (2013, April 26). UCLA chemistry professor ordered to stand trial in fatal lab fire. *Los Angeles Times*, 26. Retrieved from http://www.latimes.com http://articles.latimes.com/2013/apr/26/local/la-me-ucla-prof-20130426

Christensen, K. (2012). Report faults professor, UCLA in death of lab assistant. *Los Angeles Times*, 21. Retrieved from http://articles.latimes.com/2012/jan/21/local/la-me-ucla-lab-20120121

Clarke, S. (2006). *Safety climate in an automobile manufacturing* plant: The effects of work environment, job communication and safety attitudes on accidents and unsafe behavior. *Personnel Review*, 35(4), 413-430.

Cook, C. (2015). Minor Explosion at Chemistry Building. *Texas Tech University News*, 02. Retrieved February 2, 2015 from http://today.ttu.edu/2015/02/minor-explosion-at-chemistry-building/

Davis, J.H., Schoorman, F.D., Mayer, R.C., & Tan, H.H. (2000). The Trusted General Manager and Business Unit Performance: Empirical Evidence of a Competitive Advantage. *Strategic Management Journal*, 21(5), 563-576.

Dirks, K.T. & Ferrin, D.L. (2002). Trust in leadership: Meta-analytic findings and implications for research and practice. *Journal of Applied Psychology*, 87(4), 611-628.

DSS Research (2013). Statistical Power Calculator. Researcher's Toolkit. Retrieved November 20, 2013 from https://www.dssresearch.com/KnowledgeCenter/toolkitcalculators/statisticalpowercalculators.aspx.

Gibson, J.H., & Wayne, N.L. (2013). Proceedings of the 2012 University of California Center for Laboratory Safety Workshop. *Journal of Chemical Health and Safety*, 20(1), 4-17.

Gutierrez, J. M. (2011). A Multi-Site Pilot Test Study to Measure Safety Climate in the University Work Setting. *ProQuest LLC*.

Gutiérrez, J.M., Emery, R.J., Whitehead, L.W., & Felknor, S.A. (2013). A means for measuring safety climate in the university work setting. *Journal of Chemical Health & Safety*, 658, 1-10. doi:10.1016/j.jchas.2013.07.001.

Hardin, R. (1996). Trustworthiness. Ethics, 107, 26-42.

Hofmann, D.A., 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), 286–296.

Johnson, J & Kemsley, J. (2011 October 19). Academic Lab Safety Under Exam. *Chemical & Engineering News*, 89(43). Retrieved from https://pubs.acs.org/cen/government/89/8943gov1.html

Kath, L.M., Magley, V.J., & Marmet, M. (2010). The role of organizational trust in safety climate's influence on organizational outcomes. *Accident Analysis and Prevention*, 42(1), 2010.

Keren, N., Mills, T.R., Freeman, S.A., & Shelley, M.C. (2009). Can level of safety climate predict level of orientation toward safety in a decision-making task? *Safety Science*, 47(10), 1312-1323.

Kernsley, J. (22 January 2009). Researcher Dies After Lab Fire. *Chemical & Engineering News, Latest News*. Retrieved from http://cen.acs.org.proxy.lib.iastate.edu/articles/87/web/2009/01/Researcher-Dies-Lab-Fire.html

Kines, P., Andersen, L. P. S., Spangenberg, S., Mikkelsen, K. L., Dyreborg, J., and Zohar, D. (2010). Improving construction site safety through leader-based verbal safety communication, *Journal of Safety Research*, 41, 399-406.

Kramer, R.M. & Pittinsky, T.L. (Eds.). (2009). *Restoring Trust in Organizations and Leaders: Enduring Challenges and Emerging Answers.* Oxford University Press. doi:10.1093/acprof:oso/9780199756087.001.0001

Kramer, R.M. & Cook, K.S. (Eds.). (2004). *Trust and distrust in organizations: Dilemmas and approaches*. Russell Sage Foundation: New York.

Kramer, R.M. (1999). Trust and Distrust in Organizations: Emerging Perspectives, Enduring Questions, *Annual Review Psychology*, 50, 569-598.

Kuhn, T. S. (1970). *The structure of scientific revolutions*. University of Chicago Press.

Lacey, J., Williams, S.P., and Rizzo, M. (2014). Superior Court of the State of California for the County of Los Angeles, Deferred Prosecution Agreement, Case No. BA 392069. Retrieved from https://www.documentcloud.org/documents/1202952-2014-06-20-harran-settlemetn-agreement-from-da.html.

Lafferty, C. L. (2003). *Organizational trust in hospital nursing staffs and its relationship to three performance indicators of organizational effectiveness* (Doctoral dissertation, George Washington University).

Levin, S. L. (1999). Development of an instrument to measure organizational trust. *Dissertation Abstracts International, UMI*, (9920326).

Lodahl, J. B., & Gordon, G. (1972). The structure of scientific fields and the functioning of university graduate departments. *American Sociological Review*, 57-72.

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

Luria, G. (2008). Climate strength – How leaders form consensus. *The Leadership Quarterly*, 19, 42-53.

Luria, G., Zohar, D. and Erev, I. (2008). The effect of workers' visibility on effectiveness of intervention programs: Supervisory-based safety interventions, *Journal of Safety Research*, 39, 273-280. doi: 10.1016/j.jsr.2007.12.003

Mayer, R.C. & Gavin, M.B. (2005). Trust in management and performance: Who minds the shop while the employees watch the boss? *Academy of Management Journal*, 48(5), 874-888.

Mayer, R.C., Davis, J.H. & Schoorman, F.D. (1995). An integrative model of organizational trust. *Academy of Management Review*, 20(3), 709-734.

Mosher, G. A., Keren, N., Freeman, S. A. & Hurburgh, C. R. (2013). Employee Trust and Its Influence on Quality Climate at Two Administrative Levels, *Journal of Technology, Management, and Applied Engineering*, 29(2), 2-12.

Mosher, G.A. (2013). Trust, Safety, and Employee Decision-Making: A Review of Research and Discussion of Future Directions, *Journal of Technology, Management, and Applied Engineering*, 29(1), 2-11.

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).

National Research Council (US). Committee on Prudent Practices for Handling, Storage, & Disposal of Chemicals in Laboratories. (1995). Prudent practices in the laboratory: handling and disposal of chemicals. National Academies Press.

Nature Editorial Panel. (2011 April 21). Accidents in waiting. *Nature*, 472, 259. Retrieved from http://www.nature.com.proxy.lib.iastate.edu/nature/journal/v472/n7343/full/472259a.html, doi:10.1038/472259a

Nye, J. S., Zelikow, P., & King, D. C. (Eds.). (1997). *Why people don't trust government.* Harvard University Press.

Reason, J., Parker, D., Lawton, R. (1995). A systems-approach to organizational error. *Ergonomics* 38 (8), 1708–1721.

Shockley-Zalabak, P., Ellis, K., & Winograd, G. (2000). Organizational trust: What it means, why it matters, *Organization Development Journal*, 18, 35-48.

Smith, P. C., Kendall, L., & Hulin, C. L. (1969). The measurement of satisfaction in work and retirement: A strategy for the study of attitudes. Chicago: Rand McNally.

Thompson, R.C., Hilton, T.F., Wilt, L.A. (1998). Where the safety rubber meets the shop floor: A confirmatory model of management influence on workplace safety. *Journal of Safety Research*, 29(1), 15-24.

Torrice, M. & Kemsley, J. (2014). Patrick Harran And L.A. District Attorney Reach Deal In Sheri Sangji Case. *Chemical & Engineering News*, 92(26), 4. Retrieved from http://cen.acs.org/articles/92/i26/Patrick-Harran-L-District-Attorney.html

Torrice, M. (2013). Patrick Harran To Face Felony Trial On Labor Code Violations. *Chemical & Engineering News*, 91(18), 9. Retrieved from http://cen.acs.org/articles/91/i18/Patrick-Harran-Face-Felony-Trial.html

Ursch, B. (2015). 4 people injured in explosion in Texas Tech Chemistry Building. *Lubbock Avalanche-Journal*. Retrieved from http://lubbockonline.com/local-news/2015-02-02/4-people-injured-explosion-texas-tech-chemistry-building#.VN-BofmjO-1.

U.S. Chemical Safety and Hazard Investigation Board (CSB). (2011). Case Study: Texas Tech University Lab Explosion, No. 2010-05-I-TX; Retrieved from http://www.csb.gov/assets/1/19/CSB_Study_TTU_.pdf

U.S. Chemical Safety and Hazard Investigation Board (CSB). (2011, October 20). Experimenting with Danger [Video file]; Retrieved from http://www.csb.gov/videos/experimenting-with-danger/

Whitener, E.M., Brodt, S.E., Korsgaard, M.A., & 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., Li, C., Chen, C., & Shu, C. (2008). Interaction effects of organizational and individual factors on safety leadership in college and university laboratories. *Journal of Loss Prevention in the Process Industries*, 21(1), 239-254.

Wu, T.C., Lui, C.W., & 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.

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

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

Zohar, D. (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. (2002). Modifying supervisory practices to improve subunit safety: A leadership-based intervention model. *Journal of Applied Psychology*, 87(1), 156-163.

Zohar, D. (2000). A group-level model of safety climate: Testing the effect of group climate on micro-accidents in manufacturing jobs. *Journal of Applied Psychology*, 85(4), 587-596.

Zohar, D. (1980). Safety climate in industrial organizations: Theoretical and applied implications. *Journal of Applied Psychology*, 65(1), 96-102.

CHAPTER 4.
IMPACT OF UNIVERSITY RESEARCH LABORATORY EMPLOYEES PERCEPTIONS OF TRUST AND SAFETY CLIMATE ON DEPARTMENTAL AND GROUP LEVELS OF TRUST AND SAFETY CLIMATE

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Abstract

Personnel in university research laboratories are managed by a two-tier structure with overall direction coming from the principal investigator and daily guidance from the laboratory supervisor. Research laboratories are challenged by competing research related priorities as well as maintaining a safe and compliant workplace. The employee perceptions of trust in their leadership as well as safety climate in research laboratories can be negatively impacted when competing priorities stymie safety practices possibly leading to non-compliance issues or other incidents. This study examines the relationship between employee perceptions of trust and safety climate as well as departmental affiliation and laboratory hazard classification. Laboratory workers from 480 laboratories at a large Midwestern land grant research university were invited to participate in this study through an electronic questionnaire on employee perceptions of trust and safety climate. Descriptive statistics, correlations, and regression analysis were used to determine relationships between study variables. Departmental affiliation significantly impacted employee perceptions of trust in leadership as well as safety climate. However, the laboratory hazard classification factor did not demonstrate the same relationships to trust and safety climate. This study suggests that university leadership must improve their understanding of the impact

departmental culture has on research laboratory safety climate and employee perceptions of trust for promoting a safe working environment for their employees.

Introduction

Mounting regulatory oversight is only one of many challenges and competing priorities in the university research laboratory environment. Others are developing and funding cutting edge research, producing and publishing novel research findings, seeking to attain tenure and promotion, managing laboratory staff, managing the diversity and requirements of the university structure as well as maintaining a safe and compliant workplace.

Under the strain of these challenges, laboratories may see prudent safety practices overlooked or forgotten leading to unsafe work practices and unfavorable incidents or injuries. Over the past few years, highly visible events have occurred to point the media and shed the regulatory spotlight on university research laboratories and the laboratory and university leadership. Landmark events included the fatal burns received by a University of California, Los Angeles (UCLA) chemistry research assistant, Sheharbano (Sheri) Sangji, on December 29, 2008 and the injury of Texas Tech University chemistry graduate student, Preston Brown on January 7, 2010 on the Lubbock campus. Ms. Sangji died eighteen days after an incident in which a pyrophoric material, which she was using in her experiment, exploded and caught her clothing on fire (Kemsley, 2009). Brown lost fingers on one hand, had burns on his hands and face, and injured one of his eyes when the high energy chemical he was working with detonated (U.S. Chemical Safety and Hazard Investigation Board [CSB], 2011).

In the UCLA event, Dr. Patrick Harran, endowed chair in Organic Chemistry and principal investigator for Sheri Sangji, was the first university research laboratory principal investigator to be charged for a laboratory incident (Christensen, 2012). Six years after Ms.

Sangji's death, Dr. Harran entered into a deferred prosecution agreement with the Los Angeles District Attorney on June 20, 2014 acknowledging and accepting responsibility for the laboratory conditions (Benderly, 2014; Torrice & Kemsley, 2014; Lacey, Williams, & Rizzo, 2014). The agreement fell short of convicting Dr. Harran for the death of Ms. Sangji, but it has changed the laboratory safety environment in the academic community (Benderly, 2014). The Nature Editorial Panel article "Accidents in Waiting", details the UCLA and Texas Tech events, warning the university research environment to learn from these incidents, otherwise they are endangering themselves and others (Nature, 2011).

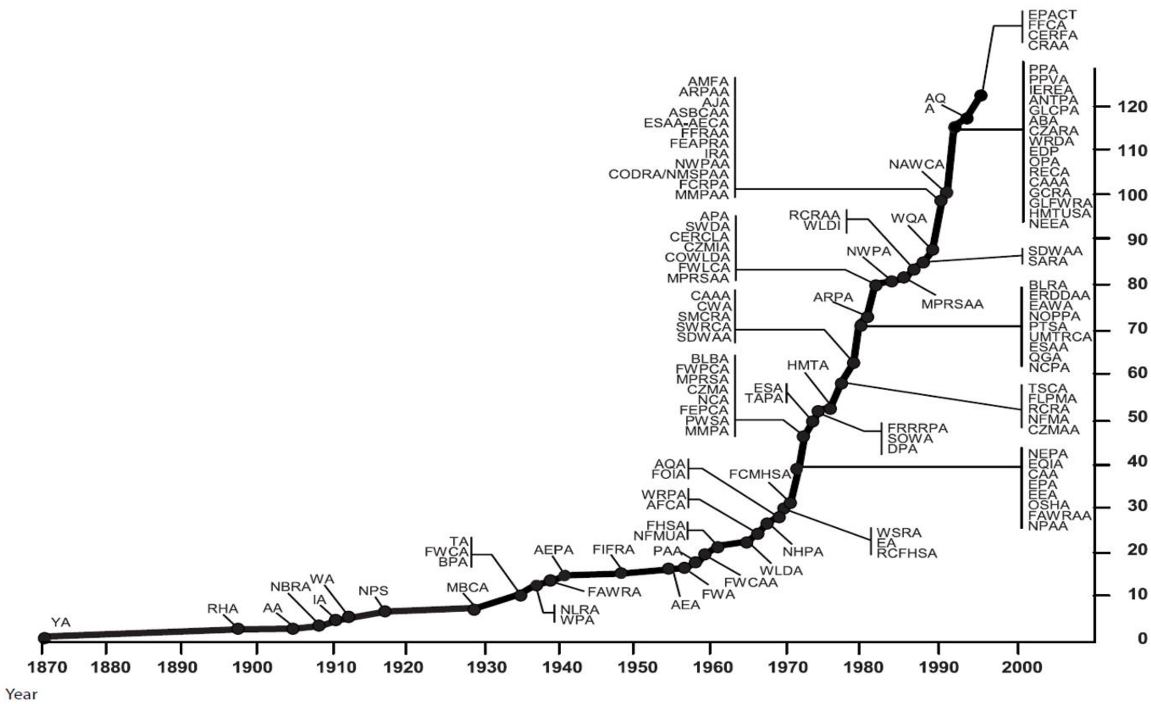
Workplace safety and the impact of significant incidents have been studied in many industries; however, little intentional research relating to workplace safety has been conducted as it relates to the university research laboratory environment (Gutiérrez et al., 2013). Employee perceptions are recognized to have an important impact on the workplace (Mosher, 2011; Das et al., 2008; Zohar & Luria, 2005). Studies have documented significant relationships between employee perceptions of trust in their organizational leadership and safety climate (Mosher, 2013; Mosher, Keren, Freeman & Hurburgh, 2013; Mosher, 2011). Many studies have focused on factors in various industries covering automobile manufacturers, agricultural businesses, aviation, chemical, and shipping (Mosher, 2011; Burt & Stevenson, 2009; Clarke, 2006; Zohar, 1980). Limited research exists in reference to how employee trust in their leadership impacts the safety climate in university research laboratories.

The evaluation of university research laboratories and their staff should not be attempted without understanding influences impacting them. Influences include affiliated academic and research departments and radiological, biological or chemical hazard classifications associated with the research performed in the laboratory.

Researchers and their laboratory workers are part of a larger guiding scientific body—their department and discipline. Studies have demonstrated several interesting dynamics, departments and scientific disciplines within the university setting seem to follow a standardized system of obtaining goals, larger and more prestigious departments are more successful than smaller ones, and scientific fields are different (Louis, Holdsworth, Anderson, & Campbell, 2007; Lodahl, 1972; Kuhn, 1970; Zuckerman, 1967; Crane, 1965). Kuhn (1970) describes the differences in disciplines as the scientific paradigm. This paradigm is described as “the entire constellation of beliefs, values, techniques, and so on shared by the members of a given [scientific] community”(p.175). Differences in scientific communities can be translated to university departments impacting every level within the department (Lodahl, 1973).

Research laboratories fall into one of three general hazard categories—radiological, biological and chemical. These classifications have different regulatory burdens. Regulatory agencies impacting research laboratories are the Occupational Safety and Health Administration (OSHA), US Environmental Protection Agency (EPA), Nuclear Regulatory Commission (NRC), National Institutes of Health (NIH), Centers for Disease Control and Prevention (CDC), Federal Aviation Administration (FAA), US Homeland Security (DHS), and a myriad of other federal, state and local agencies. When evaluating research laboratories’ regulatory requirements, an assessment of the hazards present helps define regulatory compliance and safety needs.

Regulatory agencies inspecting university research laboratories have increased over the years. Figure 1 courtesy of the Campus Consortium for Environmental Excellence (C2E2), which supports the continued improvement of environmental performance in higher education, illustrates increased environment, health, and safety regulatory oversight in the United States since the mid-1950s.



Source: Campus Consortium for Environmental Excellence
http://www.c2e2.org/What%27sChangedMay08.pdf

Figure 1. Increased environment, health, and safety regulations.

Many of these regulations impact the university research laboratory environment directly or indirectly based on their hazard classification.

Safe workplaces depend heavily on the decisions employees make on the job (Keren, Mills, Freeman, & Shelley, 2009; Zohar & Erev, 2007),therefore an increased understanding of employees perceptions of trust and safety climate may provide useful information in the development of specific safety counter measures, best practices for management, or targeted educational intervention.

Trust and safety climate have been studied and tested in many industries and certain outcomes have been documented. There is a positive relationship between factors like employee trust in their organizational leadership and the leader's encouragement to have a safe workplace (Luria, 2008). Studies also have confirmed that intermediate management has less of an impact on workers' perceptions and actions than the organizational management (Mosher et al., 2013; Zohar & Luria, 2005; Thompson, Hilton, & Witt, 1998). To date, there has been no research published on trust and safety climate in university research laboratory environments.

Trust is defined as a willingness to rely on someone to do something needed for you that you cannot manage, and a willingness to accept risk associated with that ability to let the other person help (Mosher, 2013; Dirks & Ferrin, 2002; Kramer, 1999; Mayer, Davis, & Schoorman, 1995; Shockley-Zalabak, Ellis, & Wingrad, 2000; Whitener, Brodt, Korsgaard, & Werner, 1998). Trust requires a relationship between at least two people; the trustor and the trustee (Mayer et al., 1995).

Trustworthiness must be demonstrated by leadership and management—by setting an example for their employees and gaining their trust (Whitener et al., 1998; Hardin, 1996). Organizations that support and encourage management to develop trusting relationships and reward employees for trusting can be more effective organizations (Whitener et al., 1998). There are differing definitions of trust in the relationship with the direct supervisor (e.g., laboratory supervisor) and trust in the relationship with the organizational management (e.g., principal investigator). These relationships will be different from one another (Luria, 2010; Mayer & Gavin, 2005; Dirks & Ferrin, 2002) and lead to differing work outcomes (Dirks & Ferrin, 2002). This study and possible interventions become more important in light of the fact that previous researchers have documented the fact that there is a decline in trust in our society as well as universities (Kramer & Pittinsky, 2009; Kramer & Cook, 2004; Kramer, 1999; Nye, Zelikow, & King, 1997).

Safety climate is defined as an organizational instrument that measures employee perceptions toward safety compared with other organizational outcomes (Mosher, 2013; Zohar, 2000). Like trust, there is a debate regarding the constructs of safety climate; however, safety climate is defined as “shared perceptions of the organization's practices and policies pertaining to safety” (Kath, Magley, & Marmet, 2010, p.1489).

Kath et al. (2010) found that there is agreement regarding the importance of employee perceptions of safety climate and of employee trust and comfort in participating in safety communication with their supervisor regarding needs and outcomes. Researchers have also studied the impact of human and workplace factors such as organizational tenure, coaching supervisors to include safety in their daily communications with employees, visibility of management and supervisors, and leadership (Beus, Bergman & Payne, 2010; Kines, Andersen, Spangenberg, Mikkelsen, Dyreborg & Zohar, 2010; Luria, Zohar & Erev, 2008; Luria, 2008; Zohar, 2003). Gutiérrez et al. (2013) concluded that improvements in safety climate may come through stronger relationships between the supervisor and employee as well as increased supervisory training.

Based on the literature review, there are well developed truths, 1) employees place more trust in their organizational manager than their line supervisor, 2) employees’ improved perceptions of trust in their organizational leadership has a positive impact on organizational safety climate, 3) employees’ positive attitude toward safety means a safer workplace, 4) university scientific communities (i.e., departments) are different, and 5) research laboratories have a myriad of regulatory compliance requirements impacting them and their research. Even though much has been done in many industries to measure and develop improvement strategies based on these truths, little research within the university research laboratory environment has been documented in the literature.

Methodology

Most universities are divided into colleges and services units. The primary focus of the Colleges are the academic and research areas of the institution while service units provide the day-to-day facility, academic and research support function. For the purposes of this study, the focus will be on the factors impacting colleges which are divided into departments, centers and institutes. Departmental structure is further subdivided into research groups led by principal investigators. University departments have chairpersons whose responsibilities include providing academic direction to ensure students' education makes them relevant for the workplace as well as ensuring the department maintains its accreditation. Also, the departmental chair supports researchers and their novel research in hopes of building a national reputation for the department and the researcher. Significant outcomes from these activities can be increased donations and funding from alumni and related industries, thereby securing the departments future.

The roles of the principal investigator are to provide leadership, vision, and direction that contribute to the success of the research laboratory. In many laboratories, the principal investigator spends much of his/her time developing and submitting grant applications for which they need a laboratory supervisor along with laboratory staff to perform the research. The role of the laboratory supervisor is managing research activities and laboratory workers based on guidance provided by the principal investigator. The relationships between the principal investigator, laboratory supervisor, and laboratory workers play a key role in the success of the research laboratory.

The diversity of research in university laboratories adds to the complexity of this study. Laboratory groups can be aggregated into general types based on the types of potentially hazardous materials being used and the regulatory requirement associated with their use. Hazardous, regulated materials use can be classified as radiological, biological, and chemical or physical. Radiological laboratories might include the use of radioactive materials, radiation-producing devices likes x-ray units, or lasers. Biological laboratories can be classified into biosafety level, animal biosafety levels, and plant biosafety levels as well as select agent facilities. Chemical and physical hazard laboratories can be classified as general safety laboratories. Based on these classifications and diversity of research, laboratories contain multiple hazards in many combinations making it difficult to study differences.

Two validated survey instruments were combined, modified for the research laboratory environment, and used to measure trust and safety climate to better understand the relationship between employee perceptions of trust and safety climate (Mosher, 2011; Zohar & Luria, 2005; Levin, 1999). Research by Zohar (2000, 2008) on measuring perceptions of human factors like safety climate and leadership, at two levels of management in the workplace were foundational for the study. Zohar suggested that employees have differing perceptions of the organizational leader and the employee’s supervisor due to the types and ways they communicate, interact, and respond to these management groups (Zohar, 2000; Zohar, 2008; Mosher, 2011). In other words, the organizational leader sets the direction for the workplace and the supervisor determines the steps to move the group in that direction (Zohar, 2008).

For this study, the Management Behavior Climate Assessment developed by Levin (1999) and validated by Mosher (2011) was used to measure employee perceptions of trust in their management and their supervisors (i.e., principal investigator and laboratory supervisor).

This instrument was tested and validated by Levin (1999) in several workplace environments such as manufacturing, academic, military, and government. Since Levin's initial work, other environments have been evaluated including nursing, U.S. Air Force, and grain elevator operators (Lafferty, 2003; Milligan, 2003; Mosher, 2011). This instrument consists of 40 questions using a 5-point Likert-type scale (5 = always or almost always; 4 = usually; 3 = occasionally; 2 = seldom; and 1 = rarely or never) as well as demographic and job satisfaction data. Minor modifications to the instrument included defining top management as the principal investigator and supervisor as laboratory supervisor. Demographic data included age, gender, education level, native language, safety training experience, and time in the research laboratory environment. Mosher (2011) performed confirmatory factor analysis on employee trust data confirming consistency and credibility as two main factors explaining the concept of trust. Given this understanding, mean response values from worker responses were determined for trust, consistency, and credibility.

There are two potential choices for the measurement of employee perceptions of safety climate: the Organization and Group Level Safety Climate (Zohar & Luria, 2005) instrument and the University Safety Climate Questionnaire (Gutiérrez, 2011). The University Safety Climate Questionnaire is based on Wu et al.'s (2007) safety climate instrument and has a broad focus, studying safety climate in the university workplace setting. The survey was administered to five universities in the United States for comparative analysis. Gutierrez (2011) pointed out that future safety climate surveys should focus on major groups within the university. Zohar and Luria (2005) developed the Organization and Group Level Safety Climate instrument to determine employee perceptions of safety climate for organizational management and direct supervisor. This instrument has been validated over many industries such as automobile manufacturers, agricultural businesses, aviation, chemical, and shipping (Mosher, 2011; Johnson, 2007). For purposes of this study, the Organization and Group Level Safety Climate instrument was used, since it specifically targets two levels of management within an organization. The Organization and Group Level Safety Climate instrument consisted of 32 questions using a 5-point Likert-type scale (5 = always or almost always; 4 = usually; 3 = occasionally; 2 = seldom; and 1 = rarely or never) as well as demographic data. Minor modifications to the instrument included defining top management as the principal investigator and supervisor as the laboratory supervisor. Mosher (2011) performed a factor analysis on safety climate. Her work confirmed Johnson's (2007) study determining that one factor could define the safety climate structure adequately. This assertion was validated in Zohar and Luria's research, too (Zohar & Luria, 2005). After reviewing literature regarding the measurement of employee perceptions of trust in two-levels of leadership and safety climate, determining overall trust and safety climate value for a particular research laboratory was not specifically addressed (Mosher et al., 2013, Mosher, 2011, Zohar, 2008, Johnson, 2007, Levin, 1999). Given this understanding, a mean value from worker responses was used for trust and safety climate in the study's analysis.

The instrument administration was a complex process consisting of several major steps—garnering support from the university administration and impacted principal investigators, determining sample laboratories based on hazard classification and risk ranking, and collecting laboratory worker contact information. The university has approximately 1,500 research laboratories with about 500 principal investigators. Laboratories were selected based on associated hazards—chemical, biological, and radiological—and the overall risk ranking. The risk ranking was based on audit findings for the research laboratory and particular severity levels and frequency of the findings. Findings are based on relevant federal, state and local regulations and guidelines for particular hazards in laboratories. There were approximately 200 radiological laboratories, 400 biological laboratories, and 900 chemical research laboratories within the university. Laboratories were stratified based on hazard type and risk level; 160 laboratories of each hazard type were randomly selected for this study. Principal Investigators for the selected laboratories received an email memorandum from the University Provost and the Assistant Vice President for the Department of Environmental Health and Safety requesting support for this study. Additionally, they received an email requesting potential participant names and email addresses. The potential participants were emailed a link to the electronic trust and safety climate instrument.

Research questions

The main objectives of this study were to evaluate the organizational factors such as trust and safety climate and their relationship to respondent department and laboratory hazard classification or group in university research laboratories. To this end, the following research questions were explored:

1. What is the relationship between the departmental level strength of safety climate with the group level of safety climate?

2. What is the relationship between the departmental level strength of trust with the group level of trust?

Limitations

Due to the diverse levels of organizational leadership within the university setting, communications and data management provide unique challenges to this study. The first challenge was determining which service units or departments maintain current lists of departments, research laboratories, principal investigators, laboratory supervisors, and workers. It was determined that there is no comprehensive list of laboratory workers, their laboratories, principal investigator, or laboratory supervisor on campus. The environmental health and safety department has the most comprehensive research laboratory environment database housing information that includes types of research performed in a given laboratory, its principal investigator, associated department, and non-compliance data from periodic safety related audits. However, links to the safety training database were not able to provide an accurate list of laboratory workers. For this study, the principal investigator was asked by email to provide a list of their laboratory workers and their email addresses. Approximately 50% of principal investigators contacted agreed to support this research leading to the 509 laboratory workers contacted to participate in the online survey.

Only 142 of the possible 509 people attempted to complete the survey even after three separate reminder emails. Out of the 142 participants, 110 completed all the pertinent questions on the survey. Of the 110 participants, 36 participants completed the questions that pertained to their laboratory supervisor. Possible reasons for the low sample size is that a significant majority of research laboratories do not have a designated laboratory supervisor, some respondents were laboratory supervisors, or respondents did not want to answer questions about the laboratory supervisor. This low sample size may help explain the higher standard deviation from the mean for laboratory supervisor trust and safety climate data.

Within the online survey, respondents were asked to provide their affiliated research laboratories. The survey did not have a drop down menu of select laboratory location choices, so significant data cleaning was required to identify respondent laboratories. Using demographic data and a combination of queries, laboratories were specified for each respondent.

Another potential impact on response rates in this environment is the nature of the student workers with competing priorities. More than 70% of the respondents were graduate and undergraduate students who must balance university coursework and research activities with deadlines in both. In addition, they also must deal with university distractions and timeframes. The selection of the appropriate time in the semester to administer this survey could have impacted the results. The survey went out to worker in late spring, shortly before the end of the semester, a time filled with class assignments, increased research preparation and graduation. Studying the optimal timing for conducting this research could improve the overall response rates.

The broad nature of the laboratory hazard classification system developed for this study may impact the results. Individual laboratories have the potential of working with radiological, biological and chemical materials within the same space, but have a single classification such as radiological for the purposes of this study. This complexity of the research has caused environmental health and safety departments to develop a balanced safety management and compliance programs (i.e., laboratory safety programs) for assisting research laboratories to successfully navigate regulatory compliance and provide a safer workplace (Hill, 2007; Kapin, 1999). The goal of laboratory safety programs is to combine and customize regulatory oversight needs and couple them with the development of suggested safe work practice guidance. These programs may cause the laboratory hazard classification to be irrelevant.

Results

Participants in this study consisted of laboratory workers from university research laboratories using hazardous and non-hazardous materials including radiological, biological, and chemical agents. Of the 509 email invitations, 142 responded. Of these 142 respondents, 110 provided usable data, for a response rate of 21%. The respondents were representatives from 23 departments, 58 principal investigators and 67 university research laboratories. Looking at the type of laboratory hazard associated with the respondent, 32 radiological, 34 biological, and 42 chemical laboratories were represented. Thirty seven of the 110 respondents completed the parts of the questionnaire relating to the laboratory supervisor. Possible reasons for this outcome could be, 1) the respondent's principal investigator is the laboratory supervisor, 2) the respondent is the laboratory supervisor or 3) the respondent did not answer questions regarding the laboratory

Table 1

General Respondent Demographic Data (n=105)

Gender	Male	51	49%
	Female	54	51%
Age	18-20	6	6%
	21-30	69	66%
	31-40	13	12%
	41-50	11	10%
	51-60	4	4%
	Over 61	2	2%
Status	Student	65	62%
	Faculty	1	1%
	Staff	39	37%
Education	Bachelor's	49	47%
	Master's	26	25%
	Doctoral	20	19%
	No Degree	10	10%

supervisor. Other demographic characteristics of the respondents are shown in Table 1. The total number of respondents with complete demographic data such as age and gender was 105.

Using SAS 9.4 and SPSS statistical software as well as Microsoft Excel, descriptive statistical values for the trust and safety climate variables including means, standard deviations, and correlations were determined. The mean and standard deviation data for employee perceptions of trust and safety climate controlling for department or laboratory hazard classification are detailed in Table 2. The values for the means of the variants of trust and safety climate 4.26 and 4.36, respectively.

Table 2

Means and Standard Deviations for Trust and Safety Climate based on Department and Laboratory Hazard Classification (*n*=110)

Variable	Mean	Std Dev	Minimum	Maximum
Safety Climate	4.26	0.69	2.25	5.00
Trust	4.36	0.69	2.15	5.00
Department Safety Climate	4.26	0.41	2.25	5.00
Laboratory-Type Safety Climate	4.26	0.06	4.21	4.35
Department Laboratory-Type Safety Climate	4.26	0.47	2.25	5.00
Department Trust	4.36	0.43	2.15	5.00
Laboratory-Type Trust	4.36	0.04	4.30	4.41
Department Laboratory-Type Trust	4.36	0.48	2.15	5.00

Variability in the means was seen in the standard deviations for the trust and safety climate when controlling for the variants. Variance is the average of the sum of the squared differences from the mean. There is no difference in the standard deviations for overall trust and safety climate at 0.69 with a variance of 0.47. Standard deviations for laboratory hazard classification have low variability from 0.06 for safety climate and 0.04 for trust, so the variances <0.01. For department, the variances for trust and safety climate range from 0.17 to 0.22.

The values related to the number of responses associated with hazard classification. The three classifications—biological, radiological and chemical—have 34, 32, and 44 laboratories represented in the 110 responses. Some of the data set included multiple responses per laboratory; however, the majority of laboratories had a single respondent.

The mean and standard deviation data for the individual laboratory hazard classifications are detailed in Table 3. Radiological laboratories have the lowest variability of the three types with 0.37 for safety climate and 0.40 for trust. Biological laboratories have the highest variability with 0.56 for safety climate and 0.58 for trust. Reasons for this difference could be a combination of many factors impacting these laboratories. Regulations and regulatory oversight at this university for radiological laboratories have been in place since the late 1950s. The last significant regulatory change for these radiological laboratories was in 1992. Whereas, oversight for biological laboratories began in late 1990s. The radiological safety protocols and procedures have been documented for decades; this is not the case for biological laboratories. This data could be studied more in the future.

Table 3

Means and Standard Deviations for Trust and Safety Climate based on Laboratory Hazard Classification

		Safety Climate				Trust			
Laboratory-Type	*n*	Mean	Std Dev	Max	Min	Mean	Std Dev	Max	Min
Biological	34	4.35	0.75	5	2.33	4.37	0.76	5	2.4
Chemical	44	4.21	0.69	5	2.25	4.41	0.68	5	2.15
Radiological	32	4.24	0.61	5	3	4.3	0.63	5	3.05

In contrast to laboratory hazard classifications, there are 23 departments represented in the data. Table 4 illustrates that the number of respondents for each department varied from a low of one response to a high of 14 responses.

Table 4

Means and Standard Deviations for Trust and Safety Climate based on Specific Departments

		Safety Climate				Trust			
Dept	*n*	Mean	Std Dev	Max.	Min	Mean	Std Dev	Max.	Min.
1	1	3.00	-	3.00	3.00	3.55	-	3.55	3.55
2	1	4.00	-	4.00	4.00	4.00	-	4.00	4.00
3	6	3.70	0.86	4.38	2.33	3.33	0.90	4.30	2.15
4	10	4.70	0.25	5.00	4.33	4.68	0.42	5.00	3.80
5	7	4.32	0.83	5.00	3.08	4.39	0.79	5.00	3.05
6	4	4.18	1.08	5.00	2.69	3.98	1.20	5.00	2.68
7	2	3.13	0.19	3.27	3.00	3.00	0.07	3.05	2.95
8	2	4.53	0.66	5.00	4.07	4.56	0.62	5.00	4.13
9	10	4.55	0.39	5.00	3.93	4.57	0.40	5.00	3.95
10	14	4.28	0.59	5.00	3.13	4.60	0.48	5.00	3.60
11	1	2.25	-	2.25	2.25	3.05	-	3.05	3.05
12	1	3.00	-	3.00	3.00	4.00	-	4.00	4.00
13	1	5.00	-	5.00	5.00	5.00	-	5.00	5.00
14	1	4.70	-	4.70	4.70	4.13	-	4.13	4.13
15	9	4.38	0.60	5.00	3.40	4.41	0.56	5.00	3.40
16	4	4.50	0.56	5.00	3.87	4.67	0.47	5.00	4.00
17	1	3.13		3.13	3.13	3.60		3.60	3.60
18	11	4.24	0.55	3.13	5.00	4.44	0.67	5.00	2.95
19	1	3.02		3.02	3.02	3.17		3.17	3.17
20	1	5.00		5.00	5.00	4.75		4.75	4.75
21	13	4.41	0.48	5.00	3.51	4.66	0.33	5.00	4.10
22	5	4.45	0.62	5.00	3.53	4.60	0.58	5.00	3.65
23	4	3.80	0.69	4.60	3.07	3.82	0.57	4.65	3.40

The scatterplot of the means from Table 4 shown in Figure 2 with a regression line of the data with a positive slope of 0.71 and a coefficient of determination of 0.79. These values demonstrate a strong, positive relationship trust and department, trust, safety climate.

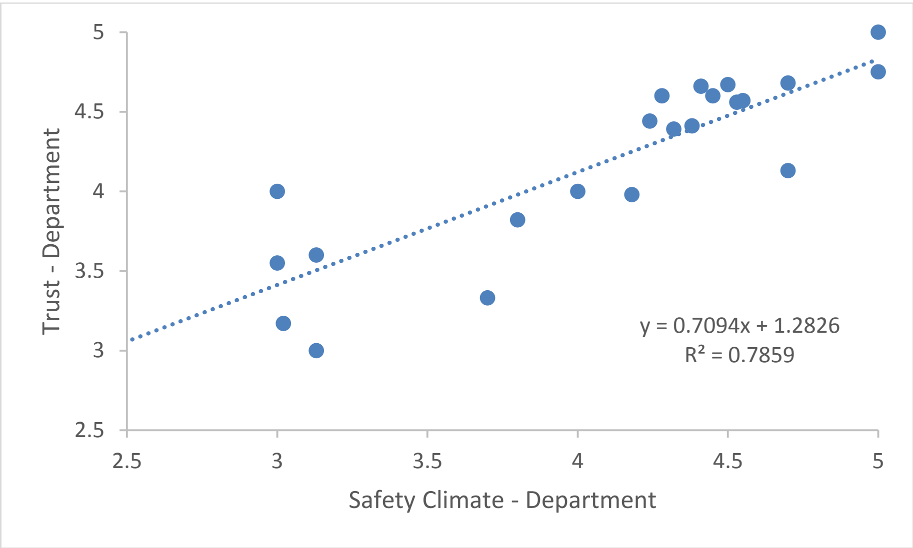


Figure 2. Means for Departmental Trust and Safety Climate (*n*=23)

Table 5 shows the means, standard deviations, and min/max values for trust and safety climate based on laboratory hazard classification and department. The respondents for the online survey represented 23 departments; however, not all departments were represented in each laboratory hazard classification. The coefficient of determination for biological, chemical, and radiological were 0.8630, 0.6852, and 0.6255. Biological laboratories have a stronger positive relationship by department than other laboratory types.

Figure 3 depicts a strong positive relationship between safety climate and employee perceptions of trust in their leadership for laboratory hazard classification and department. From the scatterplot, the coefficient of determination is 0.7141.

The descriptive statistical values found in Table 6 for departments divided into laboratory hazard classification were very similar to values found in Table 5 where laboratory hazard classifications were divided into departments. However, ten departments had only one response, so mean values were the actual trust and safety climate value for departmental responses divided into laboratory hazard classification.

Table 5

Means and Standard Deviations for Trust and Safety Climate based on Laboratory Hazard Classification and Department

			Safety Climate				Trust			
LabType	Dept	*n*	Mean	Std Dev	Max	Min	Mean	Std Dev	Max	Min
1	3	4	3.80	0.99	4.38	2.33	3.43	0.82	4.30	2.40
	4	7	4.78	0.21	5.00	4.53	4.66	0.42	5.00	3.80
	5	3	4.30	1.06	5.00	3.08	4.61	0.64	5.00	3.88
	6	2	3.83	1.61	4.97	2.69	3.84	1.64	5.00	2.68
	7	1	3.27	-	3.27	3.27	3.05	-	3.05	3.05
	9	3	4.73	0.18	4.87	4.53	4.78	0.20	4.90	4.55
	10	4	4.23	0.71	4.80	3.20	4.49	0.62	5.00	3.65
	13	1	5.00	-	5.00	5.00	5.00	-	5.00	5.00
	16	1	4.20	-	4.20	4.20	4.70	-	4.70	4.70
	17	1	3.13	-	3.13	3.13	3.60	-	3.60	3.60
	18	1	4.93	-	4.93	4.93	4.88	-	4.88	4.88
	21	1	4.93	-	4.93	4.93	5.00	-	5.00	5.00
	22	4	4.68	0.39	5.00	4.13	4.64	0.66	5.00	3.65
	23	1	3.40	-	3.40	3.40	3.55	-	3.55	3.55
2	3	2	3.49	0.78	4.04	2.93	3.14	1.40	4.13	2.15
	4	1	4.80	-	4.80	4.80	5.00	-	5.00	5.00
	6	1	4.07	-	4.07	4.07	3.25	-	3.25	3.25
	7	1	3.00	-	3.00	3.00	2.95	-	2.95	2.95
	8	2	4.53	0.66	5.00	4.07	4.56	0.62	5.00	4.13
	9	1	5.00	-	5.00	5.00	5.00	-	5.00	5.00
	10	7	4.26	0.62	4.93	3.13	4.74	0.29	5.00	4.23
	11	1	2.25	-	2.25	2.25	3.05	-	3.05	3.05
	15	8	4.50	0.51	5.00	3.80	4.54	0.44	5.00	4.00
	16	3	4.60	0.64	5.00	3.87	4.67	0.58	5.00	4.00
	18	3	3.78	0.63	4.40	3.13	4.15	1.05	4.90	2.95
	21	11	4.36	0.50	5.00	3.51	4.60	0.32	5.00	4.10
	22	1	3.53	-	3.53	3.53	4.45	-	4.45	4.45
	23	2	3.83	1.08	4.60	3.07	4.16	0.69	4.65	3.68

Table 5 (continued)

			Safety Climate				Trust			
LabType	Dept	*n*	Mean	Std Dev	Max	Min	Mean	Std Dev	Max	Min
3	1	1	3.00	-	3.00	3.00	3.55	-	3.55	3.55
	2	1	4.00	-	4.00	4.00	4.00	-	4.00	4.00
	4	2	4.37	0.05	4.40	4.33	4.58	0.60	5.00	4.15
	5	4	4.33	0.80	5.00	3.40	4.23	0.95	5.00	3.05
	6	1	5.00	-	5.00	5.00	5.00	-	5.00	5.00
	9	6	4.38	0.40	5.00	3.93	4.39	0.40	4.95	3.95
	10	3	4.40	0.55	5.00	3.93	4.45	0.74	4.95	3.60
	12	1	3.00	-	3.00	3.00	4.00	-	4.00	4.00
	14	1	4.70	-	4.70	4.70	4.13	-	4.13	4.13
	15	1	3.40	-	3.40	3.40	3.40	-	3.40	3.40
	18	7	4.33	0.41	5.00	4.00	4.50	0.56	5.00	3.65
	19	1	3.02	-	3.02	3.02	3.18	-	3.18	3.18
	20	1	5.00	-	5.00	5.00	4.75	-	4.75	4.75
	21	1	4.53	-	4.53	4.53	5.00	-	5.00	5.00
	23	1	4.13	-	4.13	4.13	3.40	-	3.40	3.40

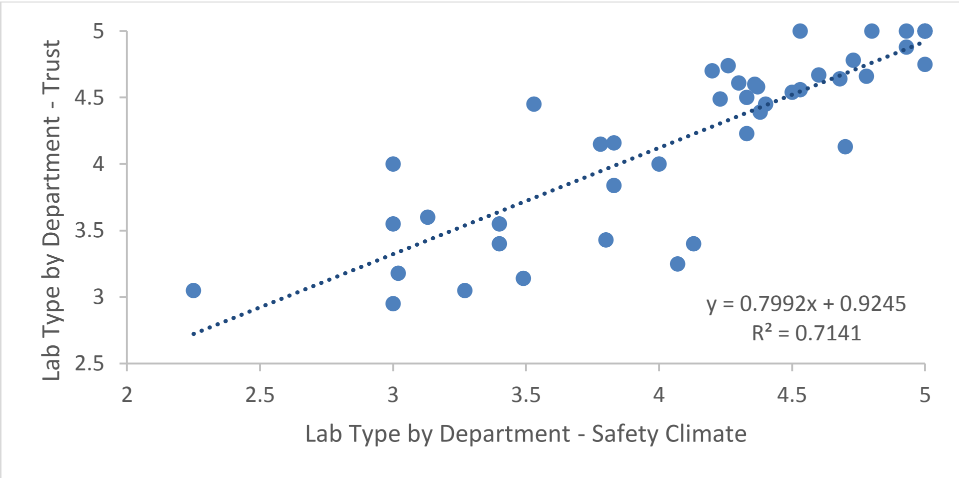


Figure 3. Means for Trust and Safety Climate based on Laboratory Hazard Classification by Department (*n*=43)

Table 6

Means and Standard Deviations for Trust and Safety Climate based on Department and Laboratory Hazard Classification

			Safety Climate				Trust			
Department	Lab-Type	*n*	Mean	Max	Min	Std Dev	Mean	Max	Min	Std Dev
1	3	1	3.00	-	3.00	3.00	3.55	-	3.55	3.55
2	3	1	4.00	-	4.00	4.00	4.00	-	4.00	4.00
3	1	4	3.80	0.99	4.38	2.33	3.43	0.82	4.30	2.40
	2	2	3.49	0.78	4.04	2.93	3.14	1.40	4.13	2.15
4	1	7	4.78	0.21	5.00	4.53	4.66	0.42	5.00	3.80
	2	1	4.80	-	4.80	4.80	5.00	-	5.00	5.00
	3	2	4.37	0.05	4.40	4.33	4.58	0.60	5.00	4.15
5	1	3	4.30	1.06	5.00	3.08	4.61	0.64	5.00	3.88
	3	4	4.33	0.80	5.00	3.40	4.23	0.95	5.00	3.05
6	1	2	3.83	1.61	4.97	2.69	3.84	1.64	5.00	2.68
	2	1	4.07	-	4.07	4.07	3.25	-	3.25	3.25
	3	1	5.00	-	5.00	5.00	5.00	-	5.00	5.00
7	1	1	3.27	-	3.27	3.27	3.05	-	3.05	3.05
	2	1	3.00	-	3.00	3.00	2.95	-	2.95	2.95
8	2	2	4.53	0.66	5.00	4.07	4.56	0.62	5.00	4.13
9	1	3	4.73	0.18	4.87	4.53	4.78	0.20	4.90	4.55
	2	1	5.00	-	5.00	5.00	5.00	-	5.00	5.00
	3	6	4.38	0.40	5.00	3.93	4.39	0.40	4.95	3.95
10	1	4	4.23	0.71	4.80	3.20	4.49	0.62	5.00	3.65
	2	7	4.26	0.62	4.93	3.13	4.74	0.29	5.00	4.23
	3	3	4.40	0.55	5.00	3.93	4.45	0.74	4.95	3.60

Table 6 (continued)

			Safety Climate				Trust			
Department	Lab-Type	*n*	Mean	Max	Min	Std Dev	Mean	Max	Min	Std Dev
11	2	1	2.25	-	2.25	2.25	3.05	-	3.05	3.05
12	3	1	3.00	-	3.00	3.00	4.00	-	4.00	4.00
13	1	1	5.00	-	5.00	5.00	5.00	-	5.00	5.00
14	3	1	4.70	-	4.70	4.70	4.13	-	4.13	4.13
15	2	8	4.50	0.51	5.00	3.80	4.54	0.44	5.00	4.13
	3	1	3.40	-	3.40	3.40	3.40	-	3.40	3.40
16	1	1	4.20	-	4.20	4.20	4.70	-	4.70	4.70
	2	3	4.60	0.64	5.00	3.87	4.67	0.58	5.00	4.00
17	1	1	3.13	-	3.13	3.13	3.60	-	3.60	3.60
18	1	1	4.93	-	4.93	4.93	4.88	-	4.88	4.88
	2	3	3.78	0.63	4.00	3.13	4.15	1.05	4.90	2.95
	3	7	4.33	0.41	5.00	4.07	4.50	0.56	5.00	3.65
19	3	1	3.02	-	3.02	3.02	3.18	-	3.18	3.18
20	3	1	5.00	-	5.00	5.00	4.75	-	4.75	4.75
21	1	1	4.93	-	4.93	4.93	5.00	-	5.00	5.00
	2	11	4.36	0.50	5.00	3.51	4.60	0.32	5.00	4.15
	3	1	4.53	-	4.53	4.53	5.00	-	5.00	5.00
22	1	4	4.68	0.39	5.00	3.53	4.64	0.66	5.00	3.65
	2	1	3.53	-	3.53	3.53	4.45	-	4.45	4.45
23	1	1	3.40	-	3.40	3.40	3.55	-	3.55	3.55
	2	2	3.83	1.03	4.60	3.07	4.16	0.69	4.65	3.68
	3	1	4.13	-	4.13	4.13	3.40	-	3.40	3.40

Figure 4 depicts a strong positive relationship between safety climate and employee perceptions of trust in their leadership for department and laboratory hazard classification. From the scatterplot, the slope of regression equation is positive at 0.80 and the coefficient of determination is 0.7141. As expected, Figure 3 and 4 are the same, since both include all trust and safety climate data.

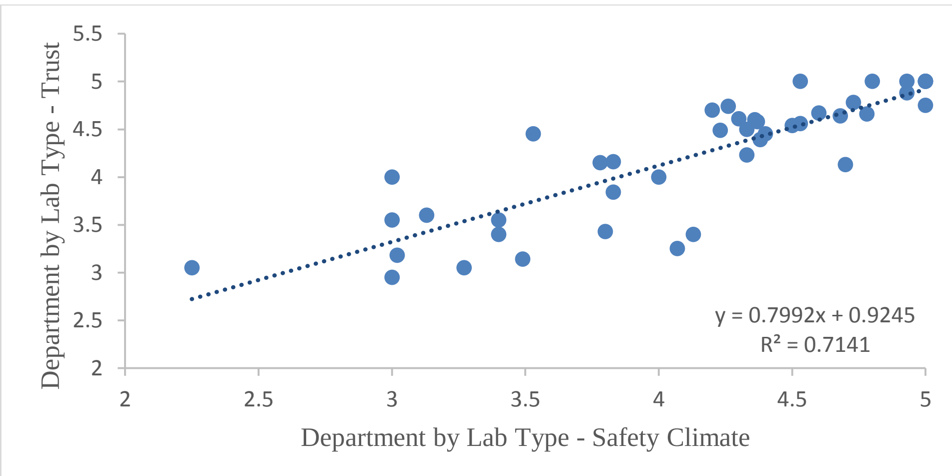


Figure 4. Means for Trust and Safety Climate based on Department by Laboratory Hazard Classification (*n*=43)

Correlation coefficients describe the amount of linear dependence variables have with each other. Table 7 details the type of relationships that exist between the categorical variables, department and laboratory hazard classification, and the continuous variables, employee perceptions of trust and safety climate within the university research laboratory environment.

Table 7

Correlation Coefficients for Department and Laboratory-Type Trust and Safety Climate Means

Variable	SC	D SC	L SC	D-L SC	T	D T	L T	D-L T
Safety Climate (SC)	1							
Departmental Safety Climate (D SC)	.601*	1						
Laboratory-Type Safety Climate (L SC)	.090	.041	1					
Departmental Laboratory-Type Safety Climate (D-L SC)	.691*	.870*	.130	1				
Trust (T)	.787*	.540*	-.010	.581*	1			
Departmental Trust (D T)	.518*	.862*	-.072	.750*	.627*	1		
Laboratory-Type Trust (L T)	-.015	.005	-.165	-.021	.064	.027	1	
Departmental Laboratory-Type Trust (D-L T)	.570*	.768*	-.015	.825*	.704*	.890*	.090	1

* indicates significance at $p \leq 0.05$, $n=110$

There are strong positive relationships between the variants of the departmental variable with trust and department safety climate. However, laboratory hazard classification of trust and safety climate demonstrates no significant relationship with other variables. The dependent variable, department, has a significant impact on safety climate and laboratory hazard classification does not have a significant impact on safety climate.

Research question 1—what is the relationship between the departmental level strength of safety climate with the group level of safety climate?— can be answered based on the analysis. The testing of department, laboratory hazard classification, and their combined interaction demonstrates that department has a significant impact on safety climate and laboratory hazard classification does not have a significant impact on safety climate. There is no significant relationship between department safety climate and group of laboratory type safety climate.

Table 8

Tests of Between-Subjects Effects with Safety Climate[(a)]

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Corrected Model	22.379[(a)]	41	.546	1.711	.026
Intercept	867.507	1	867.507	2719.176	.000
Dept	16.138	21	.768	2.409	.004
Type	.506	2	.253	.793	.457
Dept * Type	4.876	18	.271	.849	.638
Error	20.737	65	.319		
Total	2028.037	107			
Corrected Total	43.116	106			

(a) R Squared = .519

Research question 2—what is the relationship between the departmental level strength of trust with the group level of trust? There is no significant relationship between department trust and group of laboratory type trust. However, departments have a significant relationship with trust and safety climate. The testing of department, laboratory hazard classification, and their combined interaction demonstrates that department has a significant impact on trust and laboratory hazard classification does not have a significant impact on trust.

Table 9

Tests of Between-Subjects Effects with Trust

Source	Sum of Squares	*df*	Mean Square	*F*	*p*
Corrected Model	19.525[a]	41	.476	1.564	.053
Intercept	923.868	1	923.868	3033.961	.000
Dept	13.860	21	.660	2.167	.009*
Type	.357	2	.179	.586	.559
Dept * Type	5.218	18	.290	.952	.523
Error	19.793	65	.305		
Total	2128.475	107			
Corrected Total	39.318	106			

(a) R Squared = .497

Discussion

An evaluation of the results relating to the relationships between departmental and research laboratory hazard classification or group levels of safety climate is bimodal. With respect to departmental levels of safety climate, there is a strong positive relationship with employee trust levels. The strongest correlation for department level safety climate within the safety climate data is with departmental safety climate by laboratory hazard classification at 0.870. The strongest correlation for department level safety climate within the trust data is with departmental trust at 0.862.

Group level safety climate and departmental safety climate have no relationship with a correlation value of 0.041. There is little evidence to show that a strong relationship exists between group level safety climate and other levels of trust and safety climate. Group level correlation values at all departmental and group level combinations of trust or safety climate range from -0.167 to 0.130.

An evaluation of the results relating to the relationships between departmental and research laboratory hazard classification or group levels of trust is also bimodal. With respect to departmental levels of trust, there is a strong positive relationship with employee safety climate levels. The strongest correlation for department level trust within the trust data is with departmental trust by laboratory hazard classification at 0.890. The strongest correlation for department level trust within the safety climate data is with departmental safety climate at 0.862.

Group level trust and departmental trust have no relationship with a correlation value of 0.027. There is little evidence to show that a strong relationship exists between group level trust and other levels of trust and safety climate. Group level correlation values at all departmental and group level combinations of safety climate or trust range from -0.165 to 0.064. The lack of relational impact by laboratory hazard classifications may be due to the fact that biological, chemical and radiological laboratories are broad classifications and that individual laboratories have similar regulatory requirements. For example, individual radiological laboratories can use radioactive and biological materials as well as hazardous chemicals.

This study demonstrates that departments play a significant role in employee perceptions of trust in their leadership and safety climate. The strong, positive and significant relationships between departmental level of trust and departmental safety climate means that more investigation of the departments and their impact on trust and safety climate needs to be performed. Understanding the characteristics that impact trust and safety climate within departments will help to determine possible interventions at a departmental level that would lead to improved employee perceptions of trust in their leadership as well as improved safety climate within the university research laboratory environment.

Conclusions

The main objectives of this study were to evaluate employee perceptions of trust in two levels of leadership and safety climate as well as to determine interactions between employee perceptions of trust and employee perceptions of safety climate in the research laboratory environment. Based on the findings of this study, the following conclusions were drawn:

1. There is no significant relationship between the departmental level strength of safety climate with the group level of safety climate.
2. There is no significant relationship between the departmental level strength of trust with the group level of trust.

Even though no significant relationship was determined in answering the research questions, several significant, positive relationships were identified between department, employee trust, and safety climate. Interestingly, employee perceptions of trust and safety climate, controlling for department has a stronger correlation than trust and safety climate alone. A possible reason may be that departmental influences have a profound impact on research laboratories. Finally, there were no significant relationships between laboratory hazard classification, trust, and safety climate.

Recommendations for Future Research

The following are recommendations for future research based on the results of this study:

- Study the cultural similarities and differences of departmental units within the university structure to better understand these cultural impacts on employee perceptions of trust as well as safety climate.
- Study possible interventions and their impact on departmental safety climate and employee perceptions of trust in the organizational and supervisory levels of leadership in university research laboratories.
- Further research into assessing the differences between research laboratories using multiple classes of hazardous materials.
- Develop and study university and departmental safety policy changes and their impact on trust and safety climate in university research laboratories.

Recommendations for Safety Practices and Policy Improvements

The following are recommendations for possible safety practices and policy improvements that can be implemented at departmental and research laboratory group levels:

- University departments need to be deliberate in their support and reward system for safety in the research laboratory environment.
- All levels of university leadership and management should work with safety resources like the institution's environmental health and safety department to formulate possible improvements to laboratory policies and work practices.
- Laboratory supervisors should develop and implement safer work practices for their laboratory.
- The university research leadership should obtain feedback from workers on post implementation activities. For example, a directed survey could be used on a periodic basis to measure worker success of training on new work practices.
- University and departmental leadership should recognize, promote and reward safe work practices.
- Environmental health and safety departments should actively work with university and departmental leadership as well as laboratory management to develop, implement, and promote safe work practices and laboratory policies.

References

Benderly, B.L., (2014). The Landmark Patrick Harran Case Ends Inconclusively. *Science Careers from Science*. Retrieved February 14, 2015 from http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2014_07_09/caredit.a1400176

Beus, J.M., Bergman, M.E., & Payne, S.C. (2010). The influence of organizational tenure on safety climate strength: A first look. *Accident Analysis and Prevention*, 42(1), 1431-1437.

Burt, C. D., & Stevenson, R. J. (2009). The relationship between recruitment processes, familiarity, trust, perceived risk and safety. *Journal of Safety Research*, 40(5), 365-369.

Christensen, K. (2012). Report faults professor, UCLA in death of lab assistant. *Los Angeles Times*, 21. Retrieved from http://articles.latimes.com/2012/jan/21/local/la-me-ucla-lab-20120121

Clarke, S. (2006). Safety climate in an automobile manufacturing plant: The effects of work environment, job communication and safety attitudes on accidents and unsafe behavior. *Personnel Review*, 35(4), 413-430.

Cook, C. (2015). Minor Explosion at Chemistry Building. *Texas Tech University News*, 02. Retrieved February 2, 2015 from http://today.ttu.edu/2015/02/minor-explosion-at-chemistry-building/

Crane, D. (1965). Scientists at major and minor universities: A study of productivity and recognition. *American Sociological Review*, 699-714.

Dirks, K.T. & Ferrin, D.L. (2002). Trust in leadership: Meta-analytic findings and implications for research and practice. *Journal of Applied Psychology*, 87(4), 611-628.

Gutiérrez, J. M. (2011). A Multi-Site Pilot Test Study to Measure Safety Climate in the University Work Setting. *ProQuest LLC*.

Gutiérrez, J.M., Emery, R.J., Whitehead, L.W., & Felknor, S.A. (2013). A means for measuring safety climate in the university work setting. *Journal of Chemical Health & Safety*, 658, 1-10. doi:10.1016/j.jchas.2013.07.001.

Hardin, R. (1996). Trustworthiness. *Ethics*, 107, 26-42.

Hill, R. H. (2007). The emergence of laboratory safety. *Journal of Chemical Health and Safety*, 14(3), 14-19.

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

Kapin, J. M. (1999). Beyond chemical safety—an integrated approach to laboratory safety management. *Chemical Health and Safety*, 6(4), 20-22.

Kuhn, T. S. (1970). *The structure of scientific revolutions*. University of Chicago Press.

Kath, L.M., Magley, V.J., & Marmet, M. (2010). The role of organizational trust in safety climate's influence on organizational outcomes. *Accident Analysis and Prevention*, 42(1), 2010.

Keren, N., Mills, T.R., Freeman, S.A., & Shelley, M.C. (2009). Can level of safety climate predict level of orientation toward safety in a decision-making task? *Safety Science*, 47(10), 1312-1323.

Kernsley, J. (22 January 2009). Researcher Dies After Lab Fire. *Chemical & Engineering News, Latest News*. Retrieved from http://cen.acs.org.proxy.lib.iastate.edu/articles/87/web/2009/01/Researcher-Dies-Lab-Fire.html

Kines, P., Andersen, L. P. S., Spangenberg, S., Mikkelsen, K. L., Dyreborg, J., and Zohar, D. (2010). Improving construction site safety through leader-based verbal safety communication, *Journal of Safety Research*, 41, 399-406.

Kramer, R.M. & Pittinsky, T.L. (Eds.). (2009). *Restoring Trust in Organizations and Leaders: Enduring Challenges and Emerging Answers.* Oxford University Press. doi:10.1093/acprof:oso/9780199756087.001.0001

Kramer, R.M. & Cook, K.S. (Eds.). (2004). *Trust and distrust in organizations: Dilemmas and approaches*. Russell Sage Foundation: New York.

Kramer, R.M. (1999). Trust and Distrust in Organizations: Emerging Perspectives, Enduring Questions, *Annual Review Psychology*, 50, 569-598.

Lacey, J., Williams, S.P., and Rizzo, M. (2014). Superior Court of the State of California for the County of Los Angeles, Deferred Prosecution Agreement, Case No. BA 392069. Retrieved from https://www.documentcloud.org/documents/1202952-2014-06-20-harran-settlemetn-agreement-from-da.html.

Lafferty, C. L. (2003). *Organizational trust in hospital nursing staffs and its relationship to three performance indicators of organizational effectiveness* (Doctoral dissertation, George Washington University).

Levin, S. L. (1999). Development of an instrument to measure organizational trust. *Dissertation Abstracts International*, *UMI*, (9920326).

Lodahl, J. B., & Gordon, G. (1973). Differences between physical and social sciences in university graduate departments. *Research in Higher Education*, 1(3), 191-213.

Lodahl, J. B., & Gordon, G. (1972). The structure of scientific fields and the functioning of university graduate departments. *American Sociological Review*, 57-72.

Louis KS, Holdsworth JM, Anderson MS, Campbell EG (2007). Becoming a scientist: the effects of work-group size and organizational climate. *Journal of Higher Education* 78:311–336.

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

Luria, G. (2008). Climate strength – How leaders form consensus. *The Leadership Quarterly*, 19, 42-53.

Luria, G., Zohar, D. and Erev, I. (2008). The effect of workers' visibility on effectiveness of intervention programs: Supervisory-based safety interventions, *Journal of Safety Research*, 39, 273-280. doi: 10.1016/j.jsr.2007.12.003

Mayer, R.C. & Gavin, M.B. (2005). Trust in management and performance: Who minds the shop while the employees watch the boss? *Academy of Management Journal*, 48(5), 874-888.

Mayer, R.C., Davis, J.H. & Schoorman, F.D. (1995). An integrative model of organizational trust. *Academy of Management Review*, 20(3), 709-734.

Mosher, G. A., Keren, N., Freeman, S. A. & Hurburgh, C. R. (2013). Employee Trust and Its Influence on Quality Climate at Two Administrative Levels, *Journal of Technology, Management, and Applied Engineering*, 29(2), 2-12.

Mosher, G.A. (2013). Trust, Safety, and Employee Decision-Making: A Review of Research and Discussion of Future Directions, *Journal of Technology, Management, and Applied Engineering*, 29(1), 2-11.

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).

National Research Council (US). Committee on Prudent Practices for Handling, Storage, & Disposal of Chemicals in Laboratories. (1995). Prudent practices in the laboratory: handling and disposal of chemicals. *National Academies Press*.

Nature Editorial Panel. (2011 April 21). Accidents in waiting. *Nature*, 472, 259. Retrieved from http://www.nature.com.proxy.lib.iastate.edu/nature/journal/v472/n7343/full/472259a.html, doi:10.1038/472259a

Shockley-Zalabak, P., Ellis, K., & Winograd, G. (2000). Organizational trust: What it means, why it matters, *Organization Development Journal*, 18, 35-48.

Thompson, R.C., Hilton, T.F., Wilt, L.A. (1998). Where the safety rubber meets the shop floor: A confirmatory model of management influence on workplace safety. *Journal of Safety Research*, 29(1), 15-24.

Torrice, M. & Kemsley, J. (2014). Patrick Harran And L.A. District Attorney Reach Deal In Sheri Sangji Case. *Chemical & Engineering News*, 92(26), 4. Retrieved from http://cen.acs.org/articles/92/i26/Patrick-Harran-L-District-Attorney.html

U.S. Chemical Safety and Hazard Investigation Board (CSB). (2011). Case Study: Texas Tech University Lab Explosion, No. 2010-05-I-TX; Retrieved from http://www.csb.gov/assets/1/19/CSB_Study_TTU_.pdf

U.S. Chemical Safety and Hazard Investigation Board (CSB). (2011, October 20). Experimenting with Danger [Video file]; Retrieved from http://www.csb.gov/videos/experimenting-with-danger/

Whitener, E.M., Brodt, S.E., Korsgaard, M.A., & 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., Lui, C.W., & 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.

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

Zohar, D. (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. (2002). Modifying supervisory practices to improve subunit safety: A leadership-based intervention model. *Journal of Applied Psychology*, 87(1), 156-163.

Zohar, D. (2000). A group-level model of safety climate: Testing the effect of group climate on micro-accidents in manufacturing jobs. *Journal of Applied Psychology*, 85(4), 587-596.

Zohar, D. (1980). Safety climate in industrial organizations: Theoretical and applied implications. *Journal of Applied Psychology*, 65(1), 96-102.

Zohar, D. & Erev, I. (2007). On the difficulty of promoting workers' safety behavior: Overcoming the underweighting of routine tasks. *International Journal of Risk Assessment and Management*, 7(2), 122-136.

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

Zuckerman, H. (1967). Nobel laureates in science: Patterns of productivity, collaboration, and authorship. *American Sociological Review*, 391-403.

CHAPTER 5.
GENERAL CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

General review of conclusions

Conclusions Related to Employee Perceptions of Trust and Safety Climate

The main objective of Chapter 2 was to evaluate employee perceptions of trust and safety climate for two levels of leadership, and then determine relationships between employee trust and safety climate in the research laboratory environment. Following are the pertinent research questions and related findings.

1. What is the relationship between the level of employee trust in the principal investigator and the laboratory supervisor?
    - There is a significant positive relationship between the level of employee trust in the principal investigator and the laboratory supervisor.
2. What is the relationship between the level of employee ratings of safety climate in the principal investigator and the laboratory supervisor?
    - There is a significant positive relationship between the level of employee ratings of safety climate for the principal investigator and the laboratory supervisor.
3. What is the relationship between the level of employee trust in the principal investigator and the laboratory supervisor with the level of safety climate?
    - There are significant positive relationships between the level of employee trust in the principal investigator and the laboratory supervisor with the level of safety climate.

There were other findings of note in the study. First, there seems to be stronger trust and safety climate credited to the principal investigator than with the laboratory supervisor. Second, the study showed that a significant positive relationship exists between organizational trust and laboratory safety climate as well as laboratory trust and organizational safety climate. The perceptions associated with the principal investigator for both trust and safety climate had higher means and lower standard deviations than the same statistics for the perceptions associated with the laboratory supervisor. This aligns with other studies concluding that there is, generally, higher trust in the organizational level of management than the direct supervisor (Luria, 2010; Mayer & Gavin, 2005; Dirks & Ferrin, 2002). Finally, the overall trust and safety climate values were high for both the principal investigators and laboratory supervisors.

Conclusions Related to Trust and Safety Climate Regarding Incident Rates and Non-Compliance Events

The main objective of Chapter 3 was to evaluate employee perceptions of trust and safety climate and their relationship to incident rates and non-compliance events within university research laboratories. Following are the pertinent research questions and related findings.

1. What is the relationship between the level of departmental and group trust with the level of departmental incident rates?
    - There is a significant relationship between department, trust, and incident rate. There is no evidence proving any significant relationships between laboratory type, trust, and incident rates.
2. What is the relationship between the level of departmental and group safety climate with the level of organizational incident rates?
    - There is a significant relationship between department, safety climate, and incident rate. There is no evidence proving any significant relationships between department, laboratory type, safety climate, and organizational incident rates. Finally, departments have a significant relationship with trust and safety climate.
3. What is the relationship between the level of departmental and group trust with the level of departmental and group compliance rate?
    - There is a significant relationship between laboratory type, trust, and non-compliance rate. There is no evidence proving any significant relationships between department, trust, and non-compliances rates.
4. What is the relationship between the level of departmental and group safety climate with the level of departmental and group compliance rate?
    - There is no evidence proving any significant relationships between department, laboratory type, trust, and non-compliances rates. However, there is a significant relationship between laboratory type, safety climate, and procedural non-

compliance rate. However, there is a significant relationship between employee perceptions of overall research laboratory safety climate and non-compliance rate.

For both incident and non-compliance data, few departments accounted for a majority of incidents and non-compliance events. Specially, two departments doing in research using biological and chemical materials had higher incident and non-compliance rates. Punctures and lacerations events were four times more likely to happen in research laboratories than any other incident type. Six of the 86 non-compliance event types—updating hazardous material inventories and emergency action plans, performing laboratory safety surveys, ensuring that hazardous materials containers are labeled and closed, testing emergency eyewash stations and safety showers periodically, and having current safety training—accounted for 69% of all non-compliance events.

Based on these findings, initial efforts for improving safety in the research laboratory should be focused around the departments with the highest incident and non-compliance rates as well as developing specific interventions for the incident and non-compliance type with the highest rates.

Conclusions Related to Trust and Safety Climate Regarding Academic Department and Laboratory Type

The main objective of Chapter 4 was to evaluate employee perceptions of trust and safety climate and their relationship to academic department and laboratory type within university research laboratories. Following are the pertinent research questions and related findings.

1. What is the relationship between the departmental level strength of safety climate with the group level of safety climate?

- There is no significant relationship between the departmental level strength of safety climate with the group level of safety climate.

2. What is the relationship between the departmental level strength of trust with the group level of trust?
   - There is no significant relationship between the departmental level strength of trust with the group level of trust.

Even though no significant relationship were determined in answering the research questions, several significant, positive relationships were identified between department, employee trust, and safety climate. Interestingly, employee perceptions of trust and safety climate controlling for department has a stronger correlation than trust and safety climate alone. A possible reason may be that departmental influences have a profound impact on research laboratories. Finally, there were no significant relationships between laboratory hazard classification, trust, and safety climate.

Finally, this study and possible interventions become more important knowing that pervious research has determined that there is a decline in trust in our society (Kramer & Pittinsky, 2009; Kramer & Cook, 2004; Kramer, 1999). Determining ways to improve employee trust in leadership is key to a safer workplace environment.

Limitations

Due to the diverse levels of organizational leadership within the university setting, communications and data management provided unique challenges to this study. The first challenge was determining which service units or departments maintain current lists of departments, research laboratories, principal investigators, laboratory supervisors, and workers. It was determined that there is no comprehensive list of laboratory workers, their laboratories, principal investigator, or laboratory supervisor on campus. The environmental health and safety department has the most comprehensive research laboratory environment database with information that includes; types of research performed in a given laboratory, its principal investigator, associated department, and non-compliance data from periodic safety related audits. However, links to the safety training database were unavailable to provide an accurate list of laboratory workers. For this study, the principal investigators were contacted by email and asked to provide a list of the email addresses of their laboratory workers. Approximately 50% of contacted principal investigators agreed to support this research leading to the 509 laboratory workers contacted to participate in the online survey.

Only 142 of the possible 509 people attempted to complete the survey even after three separate reminders. Out of the 142 participants, 110 completed all the pertinent questions on the survey. Of the 110 participants, 36 completed the questions that pertained to their laboratory supervisor. Possible reasons for the low sample size is that a significant majority of research laboratories do not have a designated laboratory supervisor, some respondents were laboratory supervisors, or respondents did not want to answer questions about the laboratory supervisor.

Within the online survey, respondents were asked to provide their affiliated research laboratories. The survey did not have a drop down menu to select laboratory location choices, so significant data cleaning was required to identify respondent laboratories. Using demographic data and a combination of queries, laboratories were specified for each respondent.

Another potential impact on response rates in this environment is the nature of the student workers with competing priorities. More than 70% of the respondents were graduate and undergraduate students who must balance university coursework and research activities with deadlines in both. In addition, they also must deal with university distractions and timeframes. The selection of the appropriate time in the semester to administer this survey could have impacted the results. The survey went out to workers in late spring, shortly before the end of the semester, a time filled with class assignments, increased research preparation and graduation. Studying the optimal timing for conducting this research could improve the overall response rates.

Even though the response rates seem low, significant positive relationships were determined to exist between employee trust, safety climate, departments and procedural non-compliance event types.

Incident data for the respondent research laboratories were rare. There were only 3 recorded incidents which occurred in the respondent research laboratories out of the 117 incidents for all research laboratories during a 30-month period. Incident data was evaluated based on laboratory hazard classification and department; yielding no significant relationships with employee perceptions of trust and safety climate.

The broad nature of the laboratory hazard classification system developed for this study may have impacted the results. Individual laboratories have the potential of working with radiological, biological and chemical materials within the same space, but have a single classification such as radiological for the purposes of this study. This complexity of the research has caused environmental health and safety departments to develop balanced safety management and compliance programs—laboratory safety programs—for assisting research laboratories to successfully navigate regulatory compliance and provide a safer workplace (Hill, 2007; Kapin, 1999). These laboratory safety programs combine and customize regulatory oversight needs and couple them with the development of suggested safe work practice guidance. These programs may cause the laboratory hazard classification to be irrelevant.

Recommendations

Recommendations for Future Research

Based on the findings of this research the following are recommendations for future research:

- Study employee perceptions of trust and safety climate at other university research laboratories.
- Study employee perceptions of trust and safety climate at other university research laboratories and their relationships with incidents and non-compliance.
- Study department impacts on employee perceptions of trust and safety climate at other university research laboratories.
- Study possible interventions and their impact on trust and safety climate at the principal investigator and laboratory supervisor levels.
- Study possible interventions and their impact on departmental safety climate and employee perceptions of trust in the organizational and supervisory levels of leadership in university research laboratories.
- Study possible interventions and their impact on trust, safety climate, incident rates, and noncompliance events.
- Study incident and non-compliance rates at other institutions to increase understanding of their impacts on workplace safety.

- Study the cultural similarities and differences of departmental units within the university structure to better understand these cultural impacts on employee perceptions of trust as well as safety climate.
- Develop and study safety policy changes and their impact on trust and safety climate in university research laboratories.
- Develop and study safety policy changes and their impact on trust, safety climate, incident rates, and non-compliance events in university research laboratories.
- Develop and study university and departmental safety policy changes and their impact on trust and safety climate in university research laboratories.
- Further research into assessing the differences between research laboratories using multiple hazardous materials.

Recommendations for Safety Practices and Policy Improvements

The following are recommendations for possible safety practices and policy improvements that can be implemented at university research laboratories:

- Principal investigators of university research laboratories need to ensure support of the laboratory supervisor actions for implementing safer work practices in the laboratory.
- Laboratory management should recognize, promote, and reward safe work practices.
- Laboratory supervisor should develop and implement safer work practices for their laboratory workers through an evaluation of workplace hazards, laboratory protocols, and periodic audits of laboratory safety activities and non-compliance event type.

- Laboratory management should obtain feedback from the workers on safety implementation activities. For example, a directed survey could be used on a periodic basis to measure worker success of training on new work practices.
- Laboratory management should obtain feedback from the workers on post incidents or non-compliance events. For example, using regular laboratory meetings for reviewing incidents and non-compliance events for possible safety improvements.
- University, departmental, and laboratory leadership as well as laboratory workers need to support and participate in the university incident notification and investigation procedures as necessary.
- The university research leadership should obtain feedback from workers on post implementation activities. For example, a directed survey could be used on a periodic basis to measure worker success of training on new work practices.
- University and departmental leadership should recognize, promote and reward safe work practices.
- University, departmental, and laboratory leadership as well as laboratory workers need to continue to support and act on non-compliance event findings to ensure a safer workplace.
- University, departmental and laboratory management should recognize, promote, and reward safe work practices.
- All levels of university leadership and management should work with safety resources like the institution's environmental health and safety department to formulate possible improvements to laboratory policies and work practices.
- Environmental health and safety departments should continue to actively work with laboratory management as well as institutional leadership to develop, implement, and

promote safe work practices and laboratory policies like regular interactions, seminars, and research methods safety evaluation, coordinated laboratory safety, compliance audits and post-incident evaluations.

References

Dirks, K.T. & Ferrin, D.L. (2002*)*. Trust in leadership: Meta-analytic findings and implications for research and practice. *Journal of Applied Psychology*, 87(4), 611-628.

Hill, R. H. (2007). The emergence of laboratory safety. *Journal of Chemical Health and Safety*, 14(3), 14-19.

Kapin, J. M. (1999). Beyond chemical safety—an integrated approach to laboratory safety management. *Chemical Health and Safety*, 6(4), 20-22.

Kramer, R.M. & Pittinsky, T.L. (Eds.). (2009). *Restoring Trust in Organizations and Leaders: Enduring Challenges and Emerging Answers.* Oxford University Press. doi:10.1093/acprof:oso/9780199756087.001.0001

Kramer, R.M. & Cook, K.S. (Eds.). (2004). *Trust and distrust in organizations: Dilemmas and approaches*. Russell Sage Foundation: New York.

Kramer, R.M. (1999). Trust and Distrust in Organizations: Emerging Perspectives, Enduring Questions, *Annual Review Psychology*, 50, 569-598.

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

Mayer, R.C. & Gavin, M.B. (2005). Trust in management and performance: Who minds the shop while the employees watch the boss? *Academy of Management Journal*, 48(5), 874-888.

APPENDIX
REVIEW BOARD (IRB) APPROVAL INSTITUTIONAL

IRB ID: 14-080

INSTITUTIONAL REVIEW BOARD (IRB)
Application for Approval of Research Involving Humans

RECEIVED FEB 10 2014 By IRB

Title of Project: A study of safety climate and employees' trust of their organizational leadership in university research laboratories

Principal Investigator (PI): Stephen Albert Simpson		Degrees: BS, MBA
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Department: Agriculutural and Biosystems Engineering		College/Center/Institute: College of Ag and Life Sciences

PI Level: ☐ Tenured, Tenure-Eligible, & NTER Faculty ☐ Adjunct/Affiliate Faculty ☐ Collaborator Faculty ☐ Emeritus Faculty ☐ Visiting Faculty/Scientist ☐ Senior Lecturer/Clinician ☐ Lecturer/Clinician, w/Ph.D. or DVM ☒ P&S Employee, P37 & above ☐ Extension to Families/Youth Specialist ☐ Field Specialist III ☐ Postdoctoral Associate ☒ Graduate/Undergrad Student ☐ Other (specify:)

FOR STUDENT PROJECTS (*Required when the principal investigator is a student*)		
Name of Major Professor/Supervising Faculty: Dr. Steven A. Freeman		
University ID: 739468732	Phone: 515-294-9541	Email Address: sfreeman@iastate.edu
Campus Address: 106 I Ed II		Department: Agriculutural and Biosystems Engineering
Type of Project (check all that apply):	☒ Thesis/Dissertation	☐ Class Project ☐ Other (specify:)

Alternate Contact Person:	Email Address:
Correspondence Address:	Phone:

ASSURANCE

- I certify that the information provided in this application is complete and accurate and consistent with any proposal(s) submitted to external funding agencies. Misrepresentation of the research described in this or any other IRB application may constitute non-compliance with federal regulations and/or academic misconduct.
- I agree to provide proper surveillance of this project to ensure that the rights and welfare of the human subjects are protected. I will report any problems to the IRB. See Reporting Adverse Events and Unanticipated Problems for details.
- I agree that modifications to the approved project will not take place without prior review and approval by the IRB.
- I agree that the research will not take place without the receipt of permission from any cooperating institutions when applicable.
- I agree to obtain approval from other appropriate committees as needed for this project, such as the IACUC (if the research includes animals), the IBC (if the research involves biohazards), the Radiation Safety Committee (if the research involves x-rays or other radiation producing devices or procedures), etc., and to obtain background checks for staff when necessary.
- I understand that IRB approval of this project does not grant access to any facilities, materials, or data on which this research may depend. Such access must be granted by the unit with the relevant custodial authority.
- I agree that all activities will be performed in accordance with all applicable federal, state, local, and Iowa State University policies.

[redacted]

Signature of Principal Investigator Date

[redacted]

Signature of Major Professor/Supervising Faculty Date
(*Required when the principal investigator is a student*)

- I have reviewed this application and determined that departmental requirements are met, the investigator(s) has/have adequate resources to conduct the research, and the research design is scientifically sound and has scientific merit.

[redacted]

Printed Name of Department Chair/Head/Director

[redacted]

Signature of Department Chair/Head/Director Date

For IRB Use Only	Full Committee Review: ☑	Review Date: March 11, 2014
	EXPEDITED per 45 CFR 46.110(b): Category Letter	Approval/Determination Date: March 18, 2014
Approval Not Required: ☐		Approval Expiration Date: March 10, 2016
Not Research: ☐	EXEMPT per 45 CFR 46.101(b):	
No Human Subjects: ☐	Not Approved: ☐	Risk: Minimal ☑ More than Minimal ☐
IRB Reviewer's Signature [redacted]		