MODERATORS OF THE SAFETY CLIMATE-INJURY RELATIONSHIP:

A META-ANALYTIC EXAMINATION

A Thesis

by

JEREMY M. BEUS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2009

Major Subject: Psychology

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ABSTRACT

Moderators of the Safety Climate-Injury Relationship: A Meta-Analytic Examination.

(May 2009)

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This study examined the variability in the observed relationship between safety climate and injuries in the extant literature by meta-analytically examining possible moderators of the safety climate-injury relationship at both the individual and group levels of analysis. Hypotheses were posited regarding the effects of six moderators: study design (i.e., retrospective or prospective), the time frame for gathering injury data, the degree of content contamination and deficiency in safety climate measures, the source of injury data (i.e., archival or self-report), and the operationalization of injury severity. Results revealed that the safety climate-injury relationship is stronger at the group level (ρ = -.23) than at the individual level of analysis (ρ = -.18). Meaningful moderators included the time frame between the measurement of safety climate and injuries for prospective group-level studies, safety climate content contamination for group-level studies, and safety climate content deficiency for individual-level studies. Longer time frames for gathering injury data and safety climate content deficiency were found to decrease effect sizes while content contamination was associated with stronger effect sizes. Methodological recommendations are proposed for future research of the

safety climate-injury relationship including prospective longitudinal study designs with data collected and analyzed at the group-level of analysis and injuries operationalized at a greater level of severity.

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INTRODUCTION

The study of safety is of obvious organizational importance. In 2006, there were over four million non-fatal work injuries reported in the United States and more than 5,800 reported work fatalities (Bureau of Labor Statistics, 2006). In 2004, the estimated cost of workers' compensation for non-fatal injuries was $48.6 billion (Liberty Mutual Research Institute for Safety, 2006).

Safety climate is the shared perception of organizational policies, practices, and procedures pertaining to safety (Zohar, 2003). It has also been described as the relative priority of safety to production within organizations (Zohar, 2003). Past meta-analytic research has demonstrated negative relationships between safety climate and injuries (ρ = -.22, Clarke, 2006a; ρ = -.17, Nahrgang, Morgeson, & Hofmann, 2007). These results are consistent with the expectation that a safety climate that is supportive of safety (i.e., a higher climate score) will lead to fewer occupational injuries than a safety climate that is unsupportive of safety (i.e., a lower climate score; Clarke, 2006b; Probst, 2004). Further, the small to moderate magnitudes of these effect sizes is not surprising given that the safety climate-injury relationship is theoretically mediated by safety behavior (Zohar, 2003). That is, because of the mediating influence of safety behavior, the relationship between safety climate and injuries is not expected to be strong.

However, the safety climate-injury relationship has varied significantly between studies leading to inconsistent and sometimes unexpected results. Effect sizes have ranged from strongly negative (r = -.80, Baas, 2002; r = -.87, Gyekye, 2005; r = -.

This thesis follows the style of *Journal of Applied Psychology*.

61, Hofmann & Stetzer, 1996) to moderately positive (*r* = .24, Katz-Navon, Naveh, & Stern, 2005; *r* = .21, Mearns, Whitaker, & Flin, 2003; *r* = .23, Neal & Griffin, 2006), whereas others have revealed near zero relationships between safety climate and injuries (*r* = -.05, Clarke, 2006b; *r* = -.05, Michael, Evans, Jansen, & Haight, 2005; *r* = .08, Williamson, Feyer, Cairns, & Biancotti, 1997).

In a previous meta-analysis of safety climate, Clarke (2006a) found that approximately 80% of the variance in effect sizes between safety climate and injuries was unaccounted for after statistically correcting for artifacts. This large amount of unexplained variance is indicative of the presence of moderator variables (Hunter & Schmidt, 1990). Accordingly, Clarke (2006a) found that the timing of the measurement of injuries relative to the measurement of safety climate (i.e., retrospectively or prospectively; sometimes referred to as predictive and postdictive study designs) moderated the safety climate-injury relationship. Although Clarke's (2006a) findings offer some explanation for the variability in effect sizes between safety climate and injuries, it is likely that there are other factors that contribute to this heterogeneity.

An additional issue is that past safety climate meta-analyses have not examined the safety climate-injury relationship solely at the group level of analysis. This is noteworthy given that safety climate is theoretically a group-level phenomenon (Zohar, 2003). Nahrgang et al. (2007) looked only at individual-level safety climate studies, whereas Clarke (2006a) did not separate individual- and group-level studies; this latter issue is problematic because combining data from different levels of analysis may lead to incorrect interpretations of empirical estimates (Ostroff, 1993; Rousseau, 1985).

The purpose of this study is to expand upon previous meta-analyses of safety climate by meta-analytically examining the relationship between safety climate and injuries at the individual and group levels of analysis and investigating moderators associated with the timing of injury measurement and the operationalization of both safety climate and injuries. Understanding how this relationship is affected by factors associated with time and the content and measurement of safety climate and injuries will aid future research and potentially answer theoretical questions concerning how safety climate and injuries relate to one another. For example, does safety climate have the same antecedent effect on injuries as injuries have on safety climate? Further, how does the passage of time affect a given safety climate's influence on future injuries? Consequently, increased knowledge of the association between safety climate and injuries at the appropriate levels of analysis will help to improve the measurement and understanding of the state of safety within organizations.

Safety Climate

Organizational climate is derived from the tendency of individuals to attach meaning to clusters of psychologically similar events (Ostroff, Kinicki, & Tamkins, 2003; Schneider & Reichers, 1983). Organizational climate is defined as the shared perception of organizational policies, practices, and procedures (Reichers & Schneider, 1990). Because there are numerous types of related organizational events that can be linked perceptually, the concept of organizational climate is meaningless without a specific referent (Schneider & Reichers, 1983). That is, for organizational climate to have any practical meaning it must be examined as it pertains to something (e.g., safety).

To further delineate the definition of safety climate, Zohar and Luria (2005) described organizational *safety policies* as strategic goals and the means for their achievement and *safety procedures* as planned courses of action relating to those goals. These both exist at the organization level and are maintained by upper management. *Safety practices* are defined as the direct implementations of safety policies and procedures by supervisors and thus exist at the level of individual workgroups (Zohar & Luria, 2005). It is the everyday safety practices implemented by supervisors that are expected to inform individual perceptions of organizational safety policies and procedures and thus safety climate (Zohar & Luria, 2004). It is therefore possible for supervisory practices to influence safety climate perceptions regardless of whether the common practices actually correspond to existing organizational safety policy (Ostroff et al., 2003).

Levels of Analysis

Because safety climate by definition consists of *shared* safety perceptions, it is theoretically a group-level phenomenon (Zohar, 2003). That is, in order for shared perceptions to exist, there must be more than one person to perceive the given phenomenon.

Safety climate is theorized as a group-level construct, but because it is composed of individual perceptions about organizational safety, it is first measured at the individual level using the group as the referent, and subsequently aggregated to the group or organization level to represent a collective perception of safety (Ostroff et al., 2003). However, in the extant literature, safety climate perceptions are commonly not

aggregated to form group-level safety climate and thus remain at the individual level (e.g., Barling, Loughlin, & Kelloway, 2002; Clarke, 2006b; Mearns, Flin, Gordon, & Fleming, 1998; Zacharatos, Barling, & Iverson, 2005). This is potentially problematic, because according to Klein, Dansereau, and Hall (1994), analyzing a construct at a different level of analysis from that which it is said to exist theoretically "may seriously misrepresent the relationships a researcher would have found if he or she had analyzed the data at the same level as the theory" (p. 199).

Additionally, it is important to note that findings from one level of analysis can only be interpreted at that particular level (Ostroff, 1993; Rousseau, 1985). Thus, the aggregation of individual- and group-level studies in meta-analytic research may lead to erroneous interpretations of findings due to the combination of studies at differing levels of analysis.

The Safety Climate-Injury Relationship

In a theoretical model of safety climate, Zohar (2003) conceptualized safety climate as a distal antecedent of workplace injuries. Specifically, safety climate is expected to influence injury rates indirectly through its effect on behavior-outcome expectancies and subsequent safety behavior (Guldenmund, 2000; Zohar, 2003). Safety behavior (or the lack thereof) then relates to the occurrence of workplace injuries, which in turn affects an organization's safety climate (Zohar, 2003). Consequently, safety climate is not considered a direct cause of injuries. Because safety climate informs behavior-outcome expectancies, a supportive safety climate, in which safe behavior is reinforced, is expected to correspond to fewer injuries, whereas an unsupportive climate,

in which safe behavior is not reinforced, is expected to relate to more frequent injuries (Zohar, 2003). Further, although safety climate is typically conceptualized as a predictor of workplace injuries, because injuries necessarily influence climate perceptions, injuries are likewise considered to be predictive of safety climate (Zohar, 2003; see Figure 1). That is, when injuries occur, they are signals about the underlying safety climate in the organization (Spence, 1973). Therefore, safety climate is considered a contributing factor to organizational injuries and vice versa.

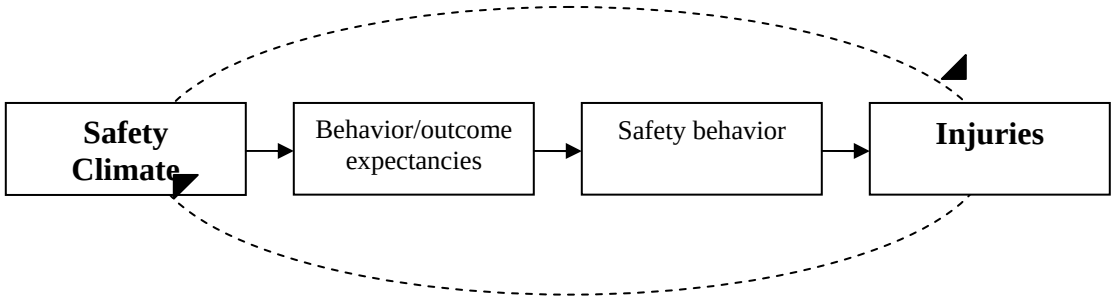

Figure 1: The safety climate-injury relationship based on Zohar (2003, Figure 6.1, p. 127).

The relationships between safety climate and injuries are likely to be influenced by unique processes at the individual and group level. For example, every individual's safety climate perception will be affected by their own idiosyncratic world views and perceptual biases (Ostroff & Bowen, 2000). These idiosyncrasies could affect how safety climate perceptions relate to workplace injuries for each person. However, when individual safety climate perceptions are aggregated to the group level, idiosyncratic perceptual biases are dissipated and the true score of safety climate is more closely approximated (Kozlowski & Klein, 2000). A closer approximation of the true safety

climate would in turn be expected to lead to better prediction of injuries at the group level.

Further, because workplace injuries are rare events (Jacobs, 1970) that are often a combination of both unsafe behavior and latent organizational weaknesses (Reason, 2000), group-level safety climate should predict injuries within a group better than individuals' safety climate perceptions would predict their own involvement in an injury. That is, although one person's perceptions about following safety rules might not result in an injury, multiple individuals' perceptions about following safety rules likely will. For instance, the probability that a specific individual will be involved in an injury for taking shortcuts is not as high as the probability that *someone* within a group will be involved in an injury given a group's general practice of taking shortcuts. Given these rationales, it is expected that group-level safety climate will relate more strongly to group injuries than individual-level safety climate perceptions will relate to individual injuries.

> *Hypothesis 1*: The relationship between group-level safety climate and injuries will be stronger than individual-level safety climate perceptions and injuries.

Moderators of the Safety Climate-Injury Relationship

Although two meta-analyses have reported small to moderate, negative relationships between safety climate perceptions and injuries (Clarke, 2006a; Nahrgang et al., 2007), the high variability among primary studies is noteworthy. Observed correlations have ranged from -.87 (Gyekye, 2005) to .24 (Katz-Navon et al., 2005).

Likewise, Clarke (2006a) found large proportions of unexplained variance in the safety climate-injury relationship. There are a number of moderators that likely contribute to the variance in the safety climate-injury relationship in the extant literature, including the timing of injury measurement, the content of safety climate measures, and injury operationalization. These moderators will be examined to expand the safety climate literature by delineating what common variants across studies attenuate or exacerbate the relationship between safety climate and workplace injuries. Level-specific hypotheses concerning moderation are not posited in the present study. It is expected that the proposed moderators operate at both the individual and group levels of analysis. Thus, the effects of each moderator are examined within the individual and group levels of analysis

Prospective versus retrospective designs[1]. In prospective designs, the measurement of safety climate precedes the measurement of injuries. Conversely, in retrospective study designs, safety climate is measured after the measurement of workplace injuries (see Figure 2).

Theoretically, organizational climate predicts behavior which in turn leads to various outcomes (Borucki & Burke, 1999; Naumann & Bennett, 2000). Applied to safety, safety climate predicts safety behavior which in turn predicts injuries (Zohar, 2003). Thus, prospective designs are consistent with theory treating safety climate as an

[1] Concurrent designs constitute a third type of study design. In concurrent designs predictor and criterion data are gathered at the same time. These designs do not lend themselves to the study of injuries. Although the self-report of injuries often occurs at the same time as the measurement of safety climate perceptions, because *previous* injuries are being self-reported, such designs are considered retrospective for the purposes of this meta-analysis.

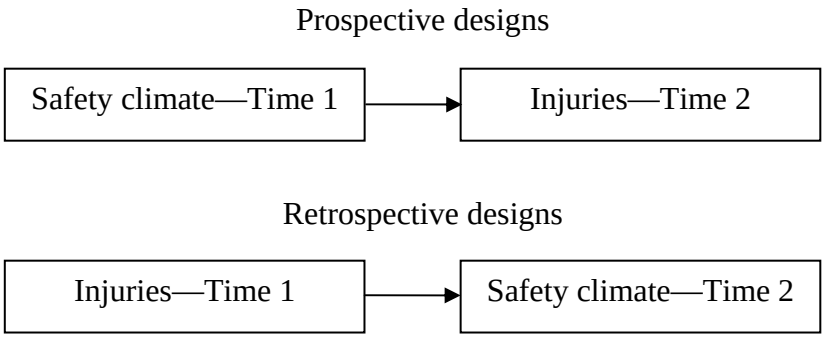

Figure 2. The timing of safety climate and injury measurement in prospective and retrospective designs.

antecedent of injuries. Consequently, safety climate is most often conceptualized as the predictor and injuries as the criterion in the extant safety climate literature. That is, hypotheses are generally posited regarding the effect of safety climate on injuries (e.g., Hofmann & Stetzer, 1996; Johnson, 2007; Mearns et al., 2003; Zohar, 2000; Zohar & Luria, 2004). This theoretical framing is common even for studies using retrospective designs, where the occurrence of injuries temporally precedes the measurement of safety climate (e.g., Clarke, 2006b; Hofmann & Stetzer, 1996; Mearns et al., 2003; Probst, 2004; Smith, Huang, Ho, & Chen, 2006).

On the other hand, past organizational events are theoretically expected to influence organizational climate in that employees reflect on these experiences when reporting their perceptions of policies, procedures, and practices (Schneider & Reichers, 1983). Therefore, prior injuries are also likely to influence current safety climate perceptions; this relationship is captured in retrospective designs. In other words, injuries are antecedents of safety climate as well (Zohar, 2003; Figure 1). Thus, theory supports both study designs: prospective, in which safety climate is an antecedent of injuries, and

retrospective, in which injuries are an antecedent of safety climate. Clarke's (2006a) meta-analysis of safety climate and injuries revealed smaller effect sizes for retrospective designs (ρ = -.22) than prospective designs (ρ = -.33). However, as noted earlier, individual- and group-level studies were combined in this meta-analysis, thus it is not clear how much study design contributed to these differential validities.

It should be noted that there is a potential threat to internal validity with prospective designs that could attenuate the safety climate-injury relationship. The measurement of safety climate could act as a safety intervention in and of itself, altering the future occurrence of injuries (Payne, Bergman, Beus, Rodriguez, & Henning, in press). That is, in a prospective design, it is possible for the measurement of safety climate to make safety a more salient organizational issue and subsequently reduce the occurrence of future injuries. The organization's response post-survey (e.g., dissemination of survey results, safety meetings, or interventions) could further change the safety climate and potentially lessen future workplace injuries. However, given Clarke's (2006a) findings that prospective designs showed stronger effects, it is difficult to determine if this is the case.

In sum, theory supports both safety climate as an antecedent of workplace injuries (prospective designs) and injuries as an antecedent of safety climate (retrospective designs) but offers little guidance as to whether one relationship should be stronger than the other. Therefore, the following exploratory research question is posed.

Research Question 1: Is the safety climate-injury relationship affected by the use of retrospective study designs versus prospective study designs?

Time frame for gathering injury data. The length of time over which injury data are gathered, either retrospectively or prospectively, is another potential source of variance in the safety climate-injury relationship. In the safety climate literature, the time frame for gathering injury data has ranged from three months (Hofmann & Mark, 2006) to more than two years (Garavan & O'Brien, 2001; Lyon, 2007; Varonen & Mattila, 2000) to the full range of employee organizational tenure (Clarke, 2006b; Huang, Ho, Smith, & Chen, 2006; Williamson et al., 1997). These vastly different time frames for gathering injury data could moderate the relationship between safety climate and injuries.

There are competing explanations as to how the safety climate-injury relationship will be affected by the length of time over which injury data are gathered. Harrison and Hulin (1989) noted that the aggregation of criterion data over long time periods can constrain causal inferences because of the increased temporal distance between the measurement of the predictor and some components of the criterion (Harrison & Hulin, 1989). That is, to accurately infer causation, the assumed cause must occur in close temporal proximity to the presumed effect (Cook & Campbell, 1979). As the time frame expands to include injuries that are more temporally distal from the measurement of safety climate, more variables have the opportunity to influence the observed relationship. For example, the acquisition of new technology or a change in existing work procedures could alter the safety climate-injury relationship, and such events are more likely to occur during longer time frames. For example, the introduction of a new

piece of equipment could lead to a temporary spike in an organization's injury rate due to worker inexperience with the new equipment.

Likewise, given a longer time period for gathering injury data, the safety climate itself could change from what it was when it was originally measured and subsequently alter the observed safety climate-injury relationship. This could occur following major organizational events such as mergers, acquisitions, unionizations, or management personnel changes. Thus, the relationship between a given measure of safety climate and injuries over a shorter time period (whether previous or subsequent) is expected to be less contaminated than the relationship between safety climate and the occurrence of injuries over a longer time period. Therefore, one possible effect of time frame on the safety climate-injury relationship could be that shorter time lags are associated with larger safety climate-injury effect sizes due to the likelihood that fewer constraints are acting on causal processes.

Alternatively, because workplace injuries are considered low base-rate organizational events (Harrison & Hulin, 1989; Jacobs, 1970), there is a smaller probability that a sufficient number of injuries will be observed over short time frames to provide sufficient variance to detect a relationship between safety climate and injuries. Hulin and Rousseau (1980) reported that a common means of studying low base-rate, or infrequent events, is to gather data from longer time intervals. This is done to provide an adequate sample of criterion data to appropriately examine empirical relationships (Hulin & Rousseau, 1980). Thus, longer time periods for gathering injury data are often needed in order to have sufficient variance to detect a relationship between safety

climate and injuries in the first place. Consequently, it may be argued that longer time periods for gathering injury data are associated with larger safety climate-injury effect sizes.

Although the length of time injury data are gathered relative to the measurement of safety climate would be expected to change the safety climate-injury relationship, due to the presence of competing rationales concerning how the relationship will be moderated (contamination vs. variance), a research question is presented here.

Research Question 2: Is the safety climate-injury relationship moderated by the time frame over which injury data are gathered?

Safety climate operationalization. Safety climate is generally considered to be a multidimensional construct (Guldenmund, 2000). However, there is little consensus as to what factors adequately constitute the construct of safety climate (Guldenmund, 2000). One reason for this is that safety climate is often conceptualized inductively by examining the safety literature and conducting interviews and focus groups to create industry- and situation-specific measures (Flin, Mearns, O'Connor, & Bryden, 2000). This common approach has led to measures with vastly different numbers and types of factors. For example, DeDobbeleer and Beland (1991) concluded, based on a factor analysis, that safety climate has two dimensions (i.e., management commitment to safety and employee involvement in safety). Conversely, Garavan and O'Brien (2001) proposed that safety climate is composed of 11 factors (e.g., management commitment to safety, the riskiness of the job, injury proneness, and negative stereotypes of safety conscious workers).

Flin et al. (2000) reviewed the safety climate literature and identified the most common factors of safety climate: management commitment to safety, safety systems, risk, work pressure, and competence. Although most common, there is no evidence that these particular factors constitute the *best* conceptualizations of the safety climate construct. Only by examining safety climate measures relative to the theoretical definition of safety climate (i.e., policies, procedures, and practices regarding workplace safety; Zohar, 2003) can it be determined whether these factors are representative conceptualizations of the safety climate construct.

According to Messick (1995), two major threats to construct validity include construct-irrelevant variance (i.e., contamination) and construct underrepresentation (i.e., deficiency). A measure is contaminated if it includes content that is not associated with the conceptual content domain (Messick, 1980). That is, if items measure more than is implied within the safety climate domain, the measure is considered contaminated. The presence of content contamination can distort the predictor-criterion relationship of interest (Messick, 1980), such that systematic contamination in a safety climate measure can correlate with measurements of injuries and subsequently bias effect sizes.

Neal and Griffin (2004) reported that a common contaminant of safety climate measures is safety attitudes, which consist of thoughts and feelings about safety rather than shared perceptions of the extent to which safety is valued in a group. Safety attitudes have been found to be related to injuries (Cree & Kelloway, 1997; Donald & Canter, 1994) and thus, to the extent that a safety climate measure also assesses safety attitudes, the safety climate-injury relationship will be strengthened. Other examples of

factors found in safety climate measures that could be related to injuries are perceptions of the riskiness of the job (Alvarado, 2003; Wu, Lu, & Liu, 2007) and individual differences in fatalism and personal safety motivation (Williamson et al., 1997). However, other contaminating factors found in safety climate measures might not be related to injuries such as perceived social support (Alvarado, 2003), employee appreciation (Baas, 2002), and job commitment (Krispin, 1997). Therefore, measurement contamination could attenuate or exacerbate the safety climate-injury relationship, because the construct-irrelevant variance could be systematically related to injuries or could increase the "noise" in the relationship. Thus, a research question concerning the effect of safety climate content contamination on the safety climate-injury relationship is proposed.

Research Question 3: Is the safety climate-injury relationship moderated by the degree of safety climate content contamination?

Conversely, deficiency is the degree to which a measure of safety climate fails to represent the complete specified content domain (Messick, 1980). Accordingly, a safety climate measure that does not assess the full content domain is considered deficient and will likely attenuate the safety climate-injury relationship. That is, because a deficient measure does not tap the full content domain, the lack of construct-relevant variance is expected to bias the safety climate-injury relationship downward.

Hypothesis 2: The safety climate-injury relationship is attenuated as the deficiency of safety climate measures increases.

Injury operationalization. Another likely source of variation in the safety climate-injury relationship is the operationalization of workplace injuries. Two potential moderators related to injury operationalization include the source of the injury data (i.e., archival or self-report) and the way injuries are defined (i.e., the level of severity required to constitute an injury).

Injury data are most often obtained from employee self-reports or archival records. Self-report injury data generally result from employee responses to survey questions and archival injury data consist of injuries that were officially reported and recorded for organizational records. Fundamentally, both types of injury data are obtained from employees and could thus both be subject to biases associated with selective reporting. However, the means with which self-report and archival injury data are gathered and the respective consequences for reporting injuries are different. These differences may in turn lead the source of the injury data to moderate the safety climate-injury relationship.

Archival injury reports are often more difficult for researchers to obtain than self-reports and have been found to suffer from substantial underreporting (Arthur, Bell, Edwards, Day, Tubre, & Tubre 2005; Burns & Wilde, 1995; Probst & Estrada, 2008). In a longitudinal study of driver crash reporting, Arthur et al. (2005) found different predictor-criterion relationships associated with the use of archival accident records versus self-reported accidents. The tendency of participants to self-report more crashes than was indicated by state archival records led to a stronger predictor-criterion relationship when using self-reported crashes than when using archival records (Arthur

et al., 2005). Likewise, in a sample from five different industries, Probst and Estrada (2008) found that for every reported injury, 2.48 injuries went unreported. Together these findings suggest that injuries are underreported in archival organizational records relative to those self-reported on surveys. Underreporting may be due to the lack of anonymity associated with reporting injuries for archival records. That is, some injuries may not be reported for archival records out of the fear of organizational consequences such as poor performance appraisals or social stigmas (e.g., being perceived by coworkers as careless, incompetent, or weak).

On the other hand, because self-reports of injuries often require respondents to recall injuries that occurred over lengthy time periods, self-reported injuries are subject to errors associated with memory bias (Landen & Hendricks, 1995). However, Schwarz (2007) contended that for “rare and important” events, self-reports do not tend to suffer as much from memory biases. Thus, given that workplace injuries are relatively “rare and important” events, injury self-reports are less likely to suffer from the same memory biases as reports of trivial or common workplace events.

Although employees are expected to remember their involvement in an injury, forward telescoping is a factor that may affect the accuracy of individual self-reports. That is, when individuals are asked to self-report past events for survey research, it is common to believe these events occurred more recently than is actually true (Prohaska, Brown, & Belli, 1998). Further, even when the date of an injury is remembered accurately, if it occurred just outside of the specified time frame (e.g., 12 months), an individual may still report the injury due to perceived relevance to the research at hand.

Thus, self-report injury data may be subject to over-reporting relative to archival injury data. The over-reporting of injuries in self-reports would thus be expected to lead to more criterion data and greater statistical power to detect effects between safety climate and injuries.

Based on these rationales, it is hypothesized that the source of injury data will moderate the relationship between safety climate and injuries. Specifically, the safety climate-injury relationship will be stronger when self-report injury data are gathered as opposed to archival injury data.

> *Hypothesis 3:* The safety climate-injury relationship is moderated by the source of injury data such that stronger relationships emerge with self-reported injury data than with archival injury data.

Injury operationalizations also differ based on the degree of severity that is required for an injury to be counted or measured. Minimum criteria for injury severity determine the range of injuries that can be included in a given study. Inclusive minimum criteria that specify that injuries are not required to be of a high level of severity lead to larger ranges of injury data than less inclusive minimum criteria for which injuries must be of a higher level of severity to be included. In studies that examined the safety climate-injury relationship, minimum inclusion criteria for injuries ranged from including nearly all injuries, including slips, trips, and other minor occurrences (Evans, Michael, Wiedenbeck, & Ray, 2004; Oliver, Cheyne, Tomas, & Cox, 2002) to injuries that required first aid treatment (Hofmann & Stetzer, 1996; Michael et al., 2005) or time off from work (Neal & Griffin, 2006).

When gathering archival injury data, safety researchers are bound by the participating organization's injury reporting criteria, which are often of such a high degree of severity that occupational injuries are too infrequent to be practically useful for research purposes (Komaki, Barwick, & Scott, 1978). For example, it is common practice for organizations to use Occupational Safety and Health Administration (OSHA) criteria for recording injuries. OSHA criteria for reportable injuries include injuries which result in death, days away from work, restricted work or transfer to another job, medical treatment beyond first aid, loss of consciousness, or diagnosis by a physician or licensed health care professional (OSHA, 2008). The severity of these injury criteria excludes injuries that are of a less serious nature from being reported (Komaki et al., 1978).

Alternatively, employees can be asked to report injuries based on their own opinion of what constitutes an injury (Clarke, 2006b; Cree & Kelloway, 1997; Donald & Canter, 1994). Thus, injuries of any and all levels of severity are eligible for inclusion. This is a means of obtaining more injury data but may also ignore meaningful differences among injuries at varying levels of severity (Jacobs, 1970). For example, the circumstances which lead to a repetitive motion injury are likely very different from those which lead to the loss of a limb. Thus the aggregation of these diverse occupational injuries may sacrifice useful information regarding the relationship between safety climate and injury severity. In a study of construction workers, Gillen, Baltz, Gassel, Kirsch, and Vaccaro (2002) found that safety climate was significantly related to injury severity (r = .18). However, the direction of the association was

unexpected, such that higher (more favorable) safety climate scores were associated with greater injury severity (Gillen et al., 2002). These findings may be due to injury reporting practices. That is, given an unfavorable safety climate, more severe injuries may occur relative to a favorable safety climate, but go unreported due to negative consequences associated with reporting injuries.

Because the minimum severity of included injuries determines the available sample of injury reports (e.g., less severe operationalizations yield more injuries eligible for reporting; see Figure 3), it is expected that the degree of injury severity will moderate the relationship between safety climate and injuries.

> *Hypothesis 4:* The safety climate-injury relationship is moderated by the severity of injury operationalizations such that operationalizations that include only severe injuries will be associated with smaller effect sizes than operationalizations that also include less severe injuries.

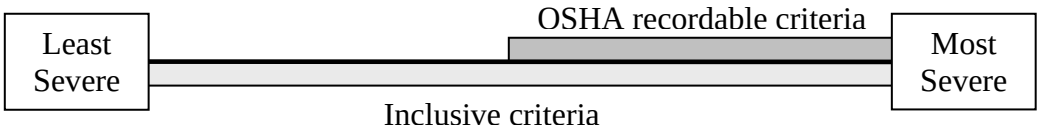

Figure 3. The continuum of injury severity (i.e., the range of inclusive injury criteria versus the range of OSHA recordable criteria).

METHOD

Literature Search

Published and unpublished studies were sought for inclusion in this meta-analysis. To locate studies, an online literature search using variants of the key words "safety climate" and "injury" or "accident" was conducted using *PsycINFO*, *PubMed*, and dissertation databases. A search of Society for Industrial and Organizational Psychology, Academy of Management, and Human Factors and Ergonomics Society conference programs from the past five years (2003-2008) was also conducted to locate studies that may as yet be unpublished. Additionally, requests for published and unpublished safety climate studies were also posted on three listservs (i.e., HRDivNet, RMNet, OBlistserv). Further, researchers in the fields of safety climate and injuries were contacted to inquire whether they have additional studies in their file drawers.

Inclusion Criteria

Studies were initially eligible for inclusion if they contained a measure of safety climate that was related to a measure of workplace injuries. Further, each study had to report an appropriate effect size (e.g., correlation coefficient) or have sufficient information to compute one. In cases where an overall safety climate-injury effect size was not given and factor-specific effect sizes were present, a composite effect size was computed (Nunnally, 1978; see Judge, Thoresen, Bono, & Patton, 2001).

Studies in which authors stated it was their intention to measure "safety culture," "safety attitudes," or other related constructs not explicitly referred to as safety climate, were excluded. I deemed it inappropriate to include studies in which the authors did not

specifically state the intention to measure the construct of safety climate. The inclusion of studies that intended to assess different constructs would potentially confound results, particularly concerning the moderating effects of safety climate content contamination and deficiency.

An additional inclusion criterion was that injury measures had to be based on the frequency of occurrence and not severity only. That is, studies were not included if all participants had been injured and injury severity was the dependent variable.

Multiple effect sizes within a given study were each eligible for inclusion as long as they were associated with independent samples or offered unique contributions to the moderator analyses. For example, retrospective and prospective effect sizes associated with the same sample (e.g., Payne & Bergman, 2008) were eligible for inclusion given that they both would contribute to the analysis of retrospective/prospective design as a moderator.

Missing information pertinent to moderator analyses (e.g., time frame for gathering injury data or safety climate measure used) was required for inclusion in the relevant analyses. For example, a study lacking information on injury severity would not be eligible for inclusion in the analysis of injury severity as a moderator.

These selection criteria resulted in an overall sample of k = 26 individual-level effect sizes and k = 19 group-level effect sizes. Included studies are indicated by asterisks in the reference section.

Data Coding

Each study was coded for pertinent sample statistics, aspects of study design, and information on predictor and criterion measures. Coded sample statistics included sample size, effect size (e.g., correlation coefficients), level of analysis, and reliability estimates. Some data recoding was necessary. In particular, some effect sizes were transposed so that a high score on safety climate indicated a favorable climate, so that for all effect sizes, a negative effect size indicated that more favorable safety climates are related to fewer injuries.

Coded information concerning the timing of injury measurement included the retrospective or prospective measurement of injuries and the time frame over which injury data were gathered. Other coded information included the safety climate measure used, the severity of injury operationalizations, and the source of injury data (i.e., archival or self-report).

Each study was coded by one primary coder. However, to ensure the accuracy of coding, a random subset of ten studies was selected to be coded by an additional coder. This exercise revealed 94% agreement between the two coders; discrepancies were resolved by discussion.

Meta-Analytic Procedures

This meta-analysis was conducted using Hunter and Schmidt's (2004) meta-analytic approach. According to Hall and Brannick (2002), the Hunter and Schmidt meta-analytic approach tends to produce more accurate credibility intervals than the

Hedges and Vevea (1998) meta-analytic approach and is deemed to be more appropriate when the data are attenuated and correction for artifacts is desired.

Corrections were made for sampling error and unreliability in safety climate measures. Sampling error was corrected in each effect size because no study assessed the entire population of interest and each therefore contained variance due to sampling error (Hunter & Schmidt, 2004). Likewise, because none of the safety climate measures were perfectly reliable, the effect sizes between safety climate and injuries were understated to some degree (Hunter & Schmidt, 2004). Thus, all effect sizes were corrected for unreliability in the measurement of safety climate; this was done using an artifact distribution. However, effect sizes were not corrected for unreliability in the measurement of injuries, because reliabilities are typically not reported for injury measures, in large part because injury measures are often counts rather than psychological scales. Clarke (2006a) imputed a reliability of .45 for self-reported injuries based on its use in a previous meta-analysis (Salgado, 2002). However, this reliability estimate was based on a separate, unpublished meta-analysis by Salgado, for which there was no other available information. Accordingly, it was deemed that there was not sufficient justification to correct for measurement unreliability in injury operationalization. This is a conservative decision which limits the degree to which the magnitude of meta-analytic safety climate-injury effect sizes is overstated.

Analysis of Moderators

Categorical moderators were assessed using Hunter and Schmidt's (2004) subgroup analysis. That is, separate meta-analyses were performed for each proposed

moderator condition (e.g., retrospective versus prospective designs) to allow for meta-analytic comparisons between conditions. To verify that moderators were likely to be operating, the percentage of variance explained by statistical artifacts was calculated and 95% credibility intervals were constructed. If after correcting for statistical artifacts much of the variance in effect sizes is unaccounted for, it is likely that moderators are present. Likewise, credibility intervals provide an estimate of the amount of variability across studies and suggest moderation when the interval includes zero (Hunter & Schmidt, 2004). The inclusion of zero in a credibility interval suggests that an estimate of the true validity between the variables of interest could realistically be zero (i.e., validity does not generalize; Hunter & Schmidt, 1990). If the upper 95% credibility value is less than zero, this suggests that 95% of the true safety climate-injury validities for the given condition are negative and thus consistent with expectations. However, considerable variance may still be indicated by large standard deviation values and thus still suggest moderation even when the upper credibility value is less than zero. Thus, moderation is expected to exist for a proposed condition if the upper credibility value is less than zero and if the standard deviations of the different moderator conditions are smaller relative to the overall population estimate's standard deviation (i.e., variance decreases after accounting for the proposed moderators). Confidence intervals were also created to provide an estimate of the accuracy of effect sizes and the extent to which sampling error is still present (Whitener, 1990). Non-overlapping confidence intervals suggest that estimates are different, whereas overlapping confidence intervals suggest no difference.

For continuous moderators, per Steel and Kammeyer-Mueller's (2002) recommendation, weighted least squares multiple regression (WLS) was used to detect moderation. Monte Carlo simulations demonstrate that this method provides the most accurate estimates and is least affected by multicollinearity, even with small sample sizes (Steel & Kammeyer-Mueller, 2002). The weighting factor used was the inverse square root of the sampling error as specified by Steel and Kammeyer-Mueller (2002). These analyses were computed in SPSS. However, because SPSS does not calculate significance values correctly in WLS multiple regression when analyzing meta-analytic data, significance levels were calculated by hand as outlined by Lipsey and Wilson (2001).

Moderators associated with the timing of injury measurement were examined hierarchically to control for the effects of second order sampling error (see Figure 4). Specifically, the effect of the time frame for injury measurement was examined within retrospective and prospective studies at the individual and group levels of analysis rather than vice versa, because time is a continuous moderator and can be examined within the simple dichotomy of retrospective or prospective study design.

Because of insufficient data points, moderators associated with the operationalization of injuries were not examined hierarchically. That is, because no group-level studies used self-report injury data and only two individual-level studies used archival injury data, there was no benefit to be gained from examining injury severity within the source of injury data or vice versa. Thus, these moderators were not nested for this meta-analysis.

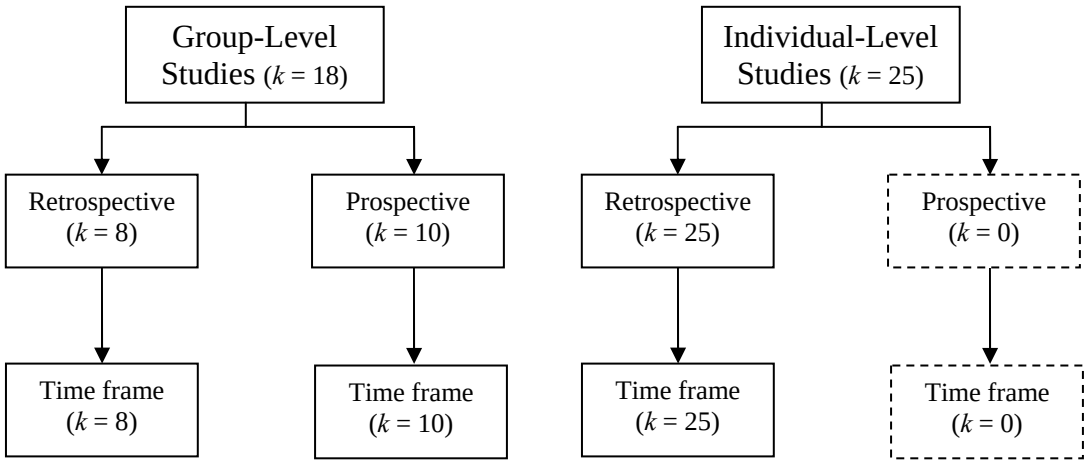

Figure 4. The hierarchical examination of moderators associated with the timing of injury measurement.

Contamination/deficiency in safety climate measures. The items used to measure safety climate for each study were gathered where available and all identifying information (e.g., names of the authors for the studies utilizing the measure) was removed. For studies where the safety climate items were not listed, authors were contacted for the items. In total, 25 measures were evaluated from which 39 of the 43 total effect sizes in this meta-analysis were derived. Of the measures obtained, the number of items ranged from 3 to 69.

Four subject matter experts (SMEs; two professors and two doctoral students) evaluated contamination and deficiency based on divergence from or convergence with Zohar's (2003) definition of safety climate and his delineation of policies, practices, and procedures (see Appendix A for questionnaire cover sheet). Contamination was operationalized as the proportion of contaminated items in a measure. Deficiency was rated on a 7-point Likert scale ranging from not at all deficient (1) to completely deficient (7). As a preliminary step, the SMEs each rated five safety climate measures

and then met to discuss individual ratings as a means of developing a common schema for rating safety climate content contamination and deficiency. Afterwards, the SMEs rated each of the 25 scales individually and then met to reach consensus. Levels of inter-rater agreement for contamination (r_{wg} = .89) and deficiency ratings (r_{wg} = .81) were acceptable before reaching consensus.

Injury severity as a moderator. Although injury severity is conceptually continuous, because most injury reports used in safety research do not specify the severity of individual injuries, it was not possible to meta-analytically examine injury severity as a continuous moderator. For both archival and self-report data, the available injury information for each study consisted of only the minimal criteria for an injury to be reported, or included. Thus, for the present study, injury severity is indicated by the level of severity included in the study.

Based on a review of the safety climate-injury literature, injury severity was dichotomized based on whether included injuries met OSHA reporting criteria or whether minimum criteria for reporting injuries were more inclusive than OSHA (see Figure 3). For this study, “OSHA recordable criteria” included only those injuries that met OSHA reporting criteria; this grouping included only injuries of a higher level of severity. “Inclusive criteria” comprised injuries requiring first aid treatment as well as OSHA recordable injuries. Thus, a larger range of injuries is covered by the inclusive criteria category.

RESULTS

Level of Analysis

Results of the individual- and group-level meta-analyses are provided in Table 1. Hypothesis 1 proposed that the safety climate-injury relationship would be stronger at the group level of analysis than at the individual level[2]. Meta-analytic results from the present study support this hypothesis (see Table 1). At the group level of analysis, the corrected average correlation (ρ = -.23; k = 18; N = 626) was larger than the corrected average correlation at the individual level of analysis (ρ = -.18; k = 25; N = 12,095). The credibility intervals for individual- and group-level studies were of similar breadth and both upper credibility values were greater than zero (CV_u = .13 and CV_u = .18, respectively), which suggests the presence of moderator variables at the individual and group levels of analysis. Further, large proportions of variance were left unexplained after statistically correcting for artifacts (Table 1).

Retrospective versus Prospective Study Designs

Results for categorical moderator analyses are provided in Table 1. Due to the presence of competing rationales, a research question was posed concerning the moderating effects of the retrospective or prospective measurement of injuries on the safety climate-injury relationship. Because no prospective studies were conducted at the

[2] The meta-analytic combination of individual- and group-level studies resulted in a mean corrected effect size of ρ = -.19, which is nearly the same magnitude as the mean corrected effect size for individual-level studies alone. Additionally, separating group-level studies to the organization and group levels resulted in corrected mean effect sizes of ρ = -.24 and ρ = -.23 respectively. This indicates that there is little difference between organization and group-level effect sizes and offers support for their combination in this study.

individual level of analysis, the effect of retrospective versus prospective study design could only be examined at the group level.

Table 1

Meta-Analytic Results for Categorical Moderators of the Safety Climate-Injury Relationship

Variable	*k*	*N*	r_o	% var. samp error	95% CI	ρ	SDρ	% var. account for	95% CV
Group-Level	18	626	-.22	39.56	-.34 : -.10	-.23	.21	39.81	-.65 : .18
Study Design									
Prospective	10	434	-.20	34.45	-.35 : -.04	-.20	.21	34.56	-.62 : .21
Retrospective	8	192	-.27	50.28	-.46 : -.08	-.30	.21	50.75	-.71 : .11
Source of Injury Data									
Self-report data	0	---	---	---	---	---	---	---	---
Archival data	18	626	-.22	39.56	-.34 : -.10	-.23	.21	39.81	-.65 : .18
Injury Severity[a]									
Inclusive criteria	7	286	-.25	45.77	-.41 : -.08	-.26	.17	46.11	-.59 : .07
OSHA criteria	6	132	-.35	83.17	-.52 : -.18	-.38	.09	84.57	-.55:-.18
Individual-Level	25	12095	-.17	8.15	-.23 : -.11	-.18	.16	8.84	-.49 : .13
Study Design									
Prospective	0	---	---	---	---	---	---	---	---
Retrospective	25	12095	-.17	8.15	-.23 : -.11	-.18	.16	8.84	-.49 : .13
Source of Injury Data									
Self-Report data	23	11378	-.17	8.67	-.24 : -.11	-.19	.15	9.48	-.48 : .11
Archival data	2	717	-.13	5.07	-.45 : .19	-.14	.25	5.13	-.63 : .35
Injury Severity									
Inclusive criteria	17	8457	-.16	17.72	-.21 : -.11	-.17	.10	19.20	-.37 : .03
OSHA criteria	8	3638	-.21	3.83	-.36 : -.05	-.21	.23	4.02	-.67 : .24

Notes: *k* = number of safety climate-injury effect sizes; *N* = total number of participants across studies; r_o = sample weighted mean observed *r*; % var. samp err = percentage of variance attributed to sampling error; 95% CI = confidence interval—lower and upper bounds; ρ = corrected mean *r*; SDρ = standard deviation of corrected effect size; % var account for = percentage of variance attributed to corrected statistical artifacts; 95% CV = credibility interval—lower and upper bounds.
[a] Injury severity could not be determined in five studies at the group level of analysis due to injury operationalizations that did not lend themselves to a dichotomization based on OSHA inclusion criteria.

Within the group level of analysis, retrospective studies revealed a stronger effect between safety climate and injuries (ρ = -.30; *k* = 8; *N* = 192) than prospective studies (ρ

= -.20; k = 10; N = 434). Thus, in answer to the research question regarding the effect of retrospective/prospective study design on the safety climate-injury relationship, these results suggest that retrospective designs lead to larger effect sizes than prospective designs at the group level. However, upper credibility values for group-level retrospective (CV_u = .11) and prospective (CV_u = .21) studies were greater than zero which suggests that validity does not generalize for either study design and that additional moderators may be operating.

Time Frame for Gathering Injury Data

Results for the analyses of continuous moderators are provided in Table 2. The effect of the time frame for gathering injury data on the safety climate-injury relationship (Research question 2) was examined within retrospective and prospective studies due to the interrelatedness of the two moderators. That is, both the retrospective/prospective measurement of injuries and the time frame over which injury data are gathered deal with *when* injuries are measured relative to the measurement of safety climate.

The effects of the time frame for gathering injury data were tested using WLS multiple regression. Results revealed that the time frame for measuring injuries moderated the safety climate-injury relationship for group-level prospective studies. The time frame for gathering injury data accounted for 47% of the variance in group-level prospective effect sizes. However, retrospective effect sizes at the individual and group levels of analysis were not significantly moderated by time frame. For group-level retrospective effect sizes, only 6% of the variance was accounted for by the time frame for measuring injuries, and at the individual level, zero variance (R^2 = .003) in safety

Table 2

Meta-Analytic Results for Continuous Moderators of the Safety Climate-Injury Relationship

Proposed Moderators	k	Mean	SD	β	R^2	r_{cd}	$r_{xyc.d}$
Group-Level	18						
Time frame for gathering injury data							
Prospective studies	10	8.60	3.69	.68*	.47		
Retrospective studies	8	22.50	18.35	-.25	.06		
Safety climate operationalization							
Contamination (c)	15	.14	.17	-.46*	.16	.24	-.48
Deficiency (d)	15	2.88	1.26	.17			.10
Individual-Level	25						
Time frame for gathering injury data							
Time frame (prospective)	0	--	--	---	---		
Time frame (retrospective)	19	10.60	4.47	.05	.00		
Safety climate operationalization							
Contamination (c)	23	.24	.21	-.04	.14	.16	-.05
Deficiency (d)	23	2.35	1.07	.38*			.38

Notes: Moderation was examined using WLS multiple regression; k = number of safety climate-injury effect sizes; SD = standard deviation; β = beta weight; R^2 = percentage of variance attributed to moderators; r_{cd} = correlation between moderators; $r_{xyc.d}$ = correlation between safety climate-injury effect sizes and moderators; * = corresponding p-value is less than or equal to .05.

climate-injury effect sizes was explained by injury time frame. Concerning the direction of effects, the influence of time frame on group-level prospective studies revealed a positive standardized regression coefficient (β = .68, p < .05). This suggests that as the time frame for gathering injury data increases, safety climate-injury effect sizes are reduced in magnitude. That is, because the average corrected correlation between safety climate and injuries was negative, a positive beta indicates that effect sizes tended to approach zero as the time frame for gathering injuries increased. Conversely, although moderation was not significant, the effect of time frame on group-level retrospective studies revealed a negative coefficient (β = -.25, p > .05), suggesting that as time frame

lengthened, safety climate-injury effect sizes tended to become larger (i.e., more negative). Overall, the examination of this research question suggests that the time frame for gathering injury data moderates the safety climate-injury relationship (with longer time frames yielding smaller effects) for group-level prospective studies but not for retrospective studies at either level of analysis. There were no individual-level prospective studies, so no conclusion can be drawn regarding the research question for these types of study designs.

Safety Climate Content Contamination and Deficiency

The effects of safety climate content contamination and deficiency on the safety climate-injury relationship were tested using WLS multiple regression. Both proposed moderators were entered simultaneously into individual- and group-level regression equations to account for shared variance. At the group level, the combined effects of safety climate content contamination and deficiency accounted for 16% of the variance in effect sizes. At the individual level of analysis, contamination and deficiency accounted for 14% of the variance in safety climate-injury effect sizes.

Safety climate content contamination. A third research question was proposed to determine if safety climate content contamination would moderate the safety climate-injury relationship. Results were mixed. The degree of contamination in safety climate measures used for group-level studies significantly moderated the safety climate-injury relationship, whereas contamination in measures used in individual-level studies was not a significant source of moderation. Independent of deficiency, contamination explained 14% of the variance at the group level and zero variance (R^2 = .002) in safety climate-

injury effect sizes at the individual level. Although only a significant moderator for group-level studies, the direction of contamination effects was consistent at both the group (β = -.46, p < .05) and individual (β = -.04, p > .05) levels of analysis, such that safety climate content contamination tended to increase safety climate-injury effect sizes. That is, because the relationship between safety climate and injuries is generally negative, negative regression coefficients suggest here that as content contamination increases, effect sizes become more negative and thus increase in magnitude.

Safety climate content deficiency. Hypothesis 2 proposed that deficiency in safety climate measures would moderate the safety climate-injury relationship such that deficiency would bias effect sizes downward (i.e., make effect sizes smaller). Results revealed that deficiency in safety climate measures was a significant moderator of the safety climate-injury relationship for individual-level studies but not for group-level studies. By itself, deficiency accounted for 14% of the variance in safety climate-injury effect sizes at the individual level and 1% of the variance at the group level. Although deficiency was a significant moderator only for individual-level studies, the direction of deficiency effects was consistent with expectations such that standardized regression estimates were positive at the individual (β = .38, p < .05) and group levels of analysis (β = .17, p > .05). Positive regression coefficients here suggest that as deficiency increases, effect sizes approach zero and thus decrease in magnitude. Thus, although deficiency tended to bias effect sizes downward at both levels of analysis as expected, safety climate content deficiency was a significant moderator only at the individual-level of analysis.

Source of Injury Data

Hypothesis 3 proposed that the source of injury data would moderate the safety climate-injury relationship such that self-reported injury data would be associated with larger safety climate-injury effect sizes than archival injury data. Only two of the studies at the individual level of analysis collected archival injury data (i.e., self-report data were used in the other 23 effect sizes) and none of the group-level studies used self-report injury data. Consequently, the source of injury data could not be examined as a moderator at the group level. At the individual level, self-report injury data were associated with a larger corrected mean safety climate-injury effect size (ρ = -.19; k = 23; N = 11,378) than archival injury data (ρ = -.14; k = 2; N = 717). Although self-reported data resulted in a larger mean effect size than archival data, upper credibility values were greater than zero for studies that used self-report (CV_u = .11) and archival data (CV_u = .35), suggesting that the source of injury data does not moderate the safety climate-injury relationship. Thus, Hypothesis 3 was not supported at the individual level of analysis and could not be tested at the group level of analysis.

Injury Severity

Hypothesis 4 proposed that inclusive injury criteria would lead to larger safety climate-injury effect sizes than OSHA reporting criteria. Contrary to expectation, OSHA reporting criteria yielded larger effect sizes than more inclusive injury criteria at the group (ρ = -.38 versus ρ = -.26) and individual levels of analysis (ρ = -.21 versus ρ = -.17). Validity generalized for group-level studies in which injury severity was operationalized using at least OSHA reporting criteria. That is, the upper credibility

value was less than zero (CV_u = -.21) and there was a decrease in SD_ρ in moderator conditions. Thus, injury severity was a meaningful moderator of the safety climate-injury relationship at the group level, but not the individual level of analysis. However, because the moderating effects were contrary to expectation, Hypothesis 4 was not supported.

DISCUSSION

The purpose of this meta-analysis was to examine the safety climate-injury relationship at the individual and group levels of analysis and to assess the effects of several potential moderators of that relationship. A stronger negative association was found between safety climate and injuries at the group level (ρ = -.23) than at the individual level of analysis (ρ = -.18). Credibility intervals that included zero and large proportions of unexplained variance after correcting for statistical artifacts supported a priori hypotheses concerning the presence of potential moderators at both the individual and group levels of analysis.

Retrospective/prospective study design was not found to be a meaningful moderator of the safety climate-injury relationship, although group-level, retrospective studies displayed larger safety climate-injury effect sizes than prospective studies. The time frame for gathering injury data was found to be a significant moderator for group-level prospective safety climate-injury effect sizes. Concerning the operationalization of safety climate, content contamination was found to moderate the safety climate-injury relationship for group-level studies while content deficiency moderated the safety climate-injury relationship for individual-level studies. Regarding injury operationalization, although the source of injury data was not found to be a meaningful moderator, injury severity was found to moderate at the group level of analysis. However, the direction of moderation was contrary to expectations such that OSHA reporting criteria led to larger effects than more inclusive injury criteria. Each of these findings are discussed in turn.

Level of Analysis

The overall meta-analytic estimates obtained, particularly at the individual level, are similar in magnitude and direction to previous meta-analytic results (ρ = -.22, Clarke, 2006a; ρ = -.17, Nahrgang et al., 2007). However, despite the close temporal proximity between this and previous safety climate meta-analyses, the percentage of studies included in this meta-analysis that were also included in past meta-analyses was relatively small (41%, Clarke, 2006a; 46%, Nahrgang et al., 2007; see Appendix B for study listings). Both previous meta-analyses included fewer effect sizes (k = 28 and 24, respectively) than the present meta-analysis (k = 43). It is also noteworthy that when group-level studies were separated from individual-level studies they had a larger corrected mean effect size than has been found in previous meta-analytic results that did not separate both individual- and group-level studies (i.e., Clarke, 2006a). Because primary studies at the individual level typically have much larger sample sizes than group-level studies (where sample size is the number of groups), Clarke's (2006a) meta-analysis obscured this stronger effect at the group level, as the typically larger individual-level samples give more weight to individual-level effect sizes which subsequently masks much of the influence of group-level effect sizes on overall meta-analytic estimates.

These results suggest that group-level safety climate could have a greater impact on reducing the occurrence of injuries within a group than individual safety climate perceptions have on individual injuries. This could be because the aggregation of individual safety climate perceptions to the group level averages out individual

perceptual idiosyncrasies (Kozlowski & Klein, 2000) that alter the relationship between safety climate perceptions and injuries from one person to another. Thus, group-level safety climate scores might provide more valid estimates of safety climate than individual safety climate perceptions. This is not surprising given that safety climate is theoretically a group-level phenomenon (Zohar, 2003). Further, because injuries are often a result of the unsafe behaviors of multiple individuals (Vaughan, 1999; Weick & Roberts, 1993), group-level safety climate should relate more strongly to the occurrence of injuries within a group than any one individual's safety climate perception relates to his/her involvement in an injury. The stronger effect at the group-level is particularly compelling given that group-level studies are likely to have less power (due to smaller sample sizes) than individual-level studies.

It is important to note that a potential confound of these results is the proximal source of injury data. That is, at the group level of analysis, only archival injury data were obtained, and at the individual level, 92% of the included effect sizes used self-report injury data. However, it is likely that the sole use of archival injury data at the group level understated effect sizes relative to individual-level studies which primarily used self-report injury data. Thus, the difference between the true safety climate-injury relationships at the individual and group-levels of analysis may be larger than was indicated by these results due to confounds associated with the source of injury data. Group-level studies incorporating self-reported injuries and more individual-level studies using archival injury data are needed to substantiate these findings.

Retrospective versus Prospective Study Designs

Two proposed moderators of the safety climate-injury relationship pertained to the timing of injury measurement relative to the measurement of safety climate. These included the retrospective or prospective gathering of injury data and the length of time over which injury data are gathered.

Group-level results indicate that retrospective study designs lead to larger safety climate-injury effect sizes than do prospective study designs. This suggests that injuries might be stronger antecedents of safety climate than vice versa. That is, the occurrence of an injury could worsen subsequent safety climate perceptions to a greater extent than positive safety climate perceptions reduce future injuries. This is perhaps not surprising given that safety climate's effect on injuries is theoretically mediated by behavior/outcome expectancies and safety behavior whereas injuries are theorized to have a more direct effect on safety climate perceptions (Zohar, 2003).

There are also some study implementation-related explanations as to why retrospective designs would have larger effect sizes than prospective designs. First, retrospective designs provide ready access to injury data over longer periods of time than prospective designs which often require lengthy waiting periods for gathering sufficient criterion data after measurement of the predictor (Arthur et al., 2005). Easier access to longer periods of injury data in retrospective designs in turn could lead to greater statistical power, and thus a higher likelihood of detecting the small to moderate effects that have traditionally been demonstrated between safety climate and injuries. However, the moderating effect of time lag on prospective effect sizes revealed in this study

suggests that as the time frame for gathering injuries lengthens, the relationship between safety climate and injuries actually decreases in magnitude. Thus, the shorter average time period for gathering injury data in prospective designs does not appear to be a plausible explanation as to why retrospective studies revealed a larger mean effect size than prospective studies.

A second potential explanation is that in prospective designs it is possible that the act of assessing safety climate reduces the occurrence of future injuries by making safety more salient to employees and thereby reducing unsafe behavior. That is, after completing a safety-related survey, employees might be more apt to consider safety in their work and discuss safety with their co-workers. Increased attention to safety could in turn result in a positive shift in safety climate perceptions after completion of the survey which would be expected to affect safety behavior and thus future injuries. Additionally, the organization could implement safety interventions post-survey in an attempt to improve the existing safety climate. Consequently, a reduction in injuries (i.e., criterion data) could limit the statistical power to detect effects between safety climate and injuries for prospective designs as compared to retrospective designs.

Given these explanations, it is difficult to determine whether the magnitude of differences between retrospective and prospective effect sizes resulted from stronger antecedent effects for injuries in comparison to safety climate or the reduction of future injuries as a result of measuring safety climate in prospective studies. More research is needed to tease apart these explanations. Specifically, are injuries more predictive of

safety climate than vice versa and is the act of measuring safety climate a means of reducing future injuries?

Time Frame for Gathering Injury Data

The time frame over which injury data were gathered was found to moderate the safety climate-injury relationship for group-level prospective studies but not for retrospective studies at either the group or individual levels of analysis. The direction of moderation for prospective studies was such that as the time frame for gathering injury data increased, safety climate-injury effect sizes tended to become smaller. This supports the notion that longer time intervals for gathering injury data may constrain predictor-criterion relationships due to the increased influence of extraneous variables (Harrison & Hulin, 1989). For example, in a manufacturing organization, events such as acquiring new technology or changing existing work procedures might lead to a weaker observed relationship between safety climate and injuries, because employee unfamiliarity with equipment or procedures could temporarily increase the occurrence of injuries and thus change the safety climate-injury relationship independent of the quality of the existing safety climate. An additional explanation is that given a longer period of time between the measurement of safety climate and injuries, the safety climate itself may change from the time it was assessed and subsequently weaken the observed relationship between the initial assessment of safety climate and injuries. Similarly, because injuries affect safety climate, the occurrence of multiple injuries over a long time frame would be expected to change the level, or quality, of the existing safety climate relative to its actual measurement. Thus, longer time intervals between the measurement of the

predictor and criterion provide more opportunities for extraneous variables to weaken the safety climate-injury relationship while also potentially allowing for the safety climate itself to shift.

The effect of the time frame for gathering injury data on the safety climate-injury relationship was inconsistent across levels of analysis within retrospective studies. The time frame for gathering injury data at the individual level had almost no effect while longer time frames at the group level resulted in *larger* safety climate-injury effect sizes. This is contrary to the effect of injury time frames in prospective studies in which longer periods for gathering injury data resulted in smaller effect sizes. It is unclear why the length of time for measuring injuries had different effects across levels of analysis in retrospective designs and why its effects were different retrospectively and prospectively. More research is needed to explain these inconsistencies.

Safety Climate Content Contamination

Safety climate content contamination was found to moderate the safety climate-injury relationship for group-level studies but not for individual-level studies. The direction of effects for both levels of analysis was such that greater contamination was associated with larger effect sizes. This suggests that contaminants of safety climate measures may spuriously inflate the observed relationship between safety climate and injuries. This is not surprising given that some common contaminants of safety climate measures, such as safety attitudes and risk perceptions, have demonstrated moderate to strong associations with injuries and would thus be expected to increase safety climate-injury effect sizes (Cree & Kelloway, 1997; Donald & Canter, 1994; Lee & Harrison,

2000; Wu et al., 2007). It is important to note that although content contamination appears to strengthen effect sizes, for researchers who are interested in safety climate specifically, the elimination of safety climate contaminants will provide a truer estimate of safety climate's affect on injuries.

It is unclear why contamination in group-level studies was more predictive of safety climate-injury effect sizes than contamination in individual-level studies. One explanation could be the small degree of overlap in the safety climate measures implemented across levels of analysis. Specifically, of the 25 total measures used in the primary studies obtained, 11 were used in individual-level studies only, nine were used in group-level studies only, and four measures were used at least once at each level. Measures that were used more than once tended to be used more frequently at one particular level of analysis. Accordingly, it is possible that contaminants appearing in individual-level studies are less strongly related to injuries than common contaminants found primarily in group-level studies. Unfortunately, an insufficient number of studies used any one common measure, let alone several, to include specific measures as categorical moderators in this meta-analysis. However, a distinction between safety climate contaminants that are expected to relate to injuries and those that are not expected to relate to injuries could be made to potentially explain the different effects found across levels of analysis. A more detailed analysis is forthcoming.

Safety Climate Content Deficiency

Deficiency in safety climate measures was found to moderate the safety climate-injury relationship in individual-level studies but not group-level studies. The direction

of effects at both levels of analysis was consistent with expectation such that safety climate content deficiency tended to result in smaller effect sizes. This is probably because safety climate measures that failed to cover the specified content domain lacked some of the construct-relevant variance with which to detect the true safety climate-injury relationship.

As with contamination, safety climate content deficiency did not moderate the safety climate-injury relationship in both levels of analysis. Deficiency had significant moderating effects in individual-level studies but not group-level studies. Again, this is likely due to content differences between safety climate measures that are used in individual-level studies more than group-level studies and vice versa. These results suggest that individual-level studies may be missing specific safety climate content that is in turn biasing safety climate-injury effect sizes downward more so than for group-level studies. A more detailed content analysis is needed to determine whether items measuring perceptions of safety policies, procedures, or practices are lacking and if those deficiencies have differential effects on the safety climate-injury relationship. Additional analyses are underway to determine if this is the case.

Source of Injury Data

Two moderators were proposed concerning the operationalization of injuries: the source of injury data (i.e., self-report or archival) and minimum injury severity. Although the source of injury data did not meaningfully moderate the safety climate-injury relationship, self-report injury data were associated with a larger mean safety climate-injury effect size than archival injury data at the individual level of analysis

which was consistent with expectations. This moderator could not be examined at the group level because none of the group-level studies incorporated self-reported injuries. This may be due to an inherent difficulty with aggregating self-reported injuries to the group level. That is, because some injuries will affect more than one individual, a sum of individually self-reported injuries can result in an overestimate of group injuries when aggregating self-reports. However, future research could address this by ensuring that items address both injuries that affected one individual and those that affected multiple individuals.

The finding that self-report data resulted in a larger mean safety climate-injury effect size than archival data at the individual level of analysis is likely due to injury underreporting for archival records (Arthur et al., 2005; Burns & Wilde, 1995; Probst & Estrada, 2008). A potential explanation for injury underreporting is that some employees fear organizational or social consequences tied to reporting injuries to the organization. Alternatively, the lack of negative consequences associated with the anonymous self-report of injuries for research-based surveys likely leads to more reported injuries and thus more variance to detect effects when using self-reports.

Additionally, forward telescoping may have resulted in self-reported injuries being over-reported relative to archival injuries and partially explain the larger mean effect size for studies that used self-report injury data at the individual level of analysis.

Injury Severity

Injury severity (i.e., the level of injury inclusion) was found to moderate the safety climate-injury relationship at the group level of analysis. However, contrary to

expectations, studies that used OSHA injury reporting criteria were associated with larger safety climate-injury effect sizes than studies that used more inclusive injury operationalizations. These results are unexpected because the use of OSHA injury criteria, as opposed to more inclusive criteria, will inevitably lead to smaller samples of injury data and thus less power to detect effects. However, this is based on the assumption that injuries of all levels of severity are related to safety climate.

A potential explanation for these results is that safety climate may have little effect on the occurrence of very minor injuries (e.g., slips or trips) which are perhaps more attributable to temporary distractions or individual attributes such as poor physical coordination than perceptions of safety. The inclusion of minor injuries may thus add error variance to the safety climate-injury relationship and disguise the true influence of safety climate on injuries. Alternatively, more severe injuries, which are likely a result of safety violations, are probably more associated with negative group safety perceptions (i.e., safety climate) than minor injuries which could be expected to occur independent of the quality of the prevailing safety climate. Thus, it is possible that injuries of a higher severity have a stronger negative relationship to safety climate than minor injuries.

To the contrary, Gillen et al. (2002) found that safety climate perceptions were *positively* related to injury severity. That is, the favorability of safety climate perceptions tended to increase with injury severity. However, as previously noted, Gillen et al.'s (2002) findings could have been due to poor injury reporting practices in unfavorable safety climates in the construction industry where non-reporting behaviors might be reinforced more strongly than reporting behaviors. In line with this, Probst, Brubaker,

and Barsotti (2008) found that organizations in the construction industry with poor safety climates had substantially higher rates of injury underreporting (81%) than construction organizations with positive safety climates (47%). The authors reported that whereas safety climate and the combination of reported and unreported injuries had a negative relationship (r = -.35), safety climate and reported injuries actually had a small, positive relationship (r = .07; Probst et al., 2008). This could lead to the false conclusion that favorable safety climates are positively related to injuries when they may be more strongly related to comfort with reporting health and safety concerns. More research is needed to determine if this is the case.

Limitations and Future Directions

The primary limitation of this meta-analysis was the unavailability of data to test all of the proposed moderators at both the individual and group levels of analysis. First, no individual-level prospective studies were found, so the comparison of retrospective and prospective studies at the individual level of analysis was not possible. Second, no group-level studies were found that used self-report injury data and only two individual-level studies used archival data.

A potential limitation of this study was the reliance on SME subjective ratings to assess safety climate content contamination and deficiency. However, the nature of these proposed moderators was such that safety climate content could only be assessed using qualitative judgments. Accordingly, rater effects were minimized as much as possible by using a common theoretical framework, preserving scale anonymity, and holding consensus meetings to discuss ratings. More research is needed to determine how safety

climate content contamination and deficiency affect the safety climate-injury relationship. For example, a finer grained analysis of contamination could be done in which items that assess constructs theoretically expected to relate to injuries (e.g., safety attitudes and risk perceptions) are separated from items that assess constructs not expected to relate to injuries (e.g., perceived social support, employee appreciation, job commitment). This could reveal stronger moderating effects for contamination and also explain content differences between common individual and group-level safety climate measures. For deficiency, future research could determine the degree to which deficiencies in specific aspects of Zohar's (2003) theoretical definition of safety climate (i.e., safety policies, procedures, or practices) differentially influence the safety climate-injury relationship. This could further explain deficiency differences in individual and group-level safety climate measures.

There are additional theoretical moderators at the group level of analysis that warrant further investigation. For example, groups vary in terms of how much they agree about safety climate perceptions, which is referred to as climate strength (Schneider, Salvaggio, & Subirats, 2002). Strong safety climates that are unsupportive of safety are expected to be more strongly associated with safety-related outcomes, such as injuries, than weak safety climates. A related moderator is that groups also vary in terms of the interdependence of their work. Safety climates in highly interdependent groups would be expected to relate more strongly to subsequent safety outcomes than safety climates in groups with low interdependence. Favorable safety climate perceptions would be critical for groups in which individual safety is dependent on the actions and perceptions of the

collective. Thus, future research should examine group interdependence and climate strength as moderators of the group level safety climate-injury relationship as theoretically both of these could affect this relationship.

Because many of the moderators included in this study are associated with methodological decisions when studying the safety climate-injury relationship, a number of recommendations for future primary studies can be made. First, future research of the safety climate-injury relationship should be conducted at the group-level of analysis, to be consistent with the specified theoretical level (Ostroff et al., 2003; Zohar, 2003). Second, in cases where researchers are interested in how safety climate affects the occurrence of injuries, prospective study designs should be used, as this allows more accurate causal inferences regarding the influence of safety climate on injuries. Third, longitudinal studies are needed to better determine how safety climate and injuries relate over different time periods. Longitudinal designs would also enable researchers to examine both prospective and retrospective relationships as well as better understand what is happening within time frames in which injury data are typically aggregated. Fourth, because meaningful comparisons could not be made between studies that used self-report versus archival injury data no recommendations can be made regarding the use of one source over the other; however, the use of self-report data at the group level of analysis in future research would allow for comparisons with existing studies that have incorporated archival injury data. Finally, based on meta-analytic results, injuries should be operationalized at a greater level of severity (e.g., according to OSHA

reporting criteria), as these types of injuries appear to have a more meaningful relationship to safety climate than injury criteria that include more minor injuries.

CONCLUSION

In summary, the purpose of the present study was to meta-analytically examine the relationship between safety climate and injuries at the individual and group levels of analysis and to examine the effects of six proposed moderators on that relationship. Study results revealed that the safety climate-injury relationship is stronger at the group level of analysis than the individual level, supporting the notion that safety climate is more predictive of organizational outcomes when conceptualized at the group level. The results also showed that meaningful moderators of the safety climate-injury relationship included the time frame over which injury data are gathered in group-level prospective studies, safety climate content contamination in group-level studies, content deficiency in individual-level studies, and injury severity in group-level studies. Whereas longer time frames for injury measurement and greater safety climate content deficiency were associated with decreases in safety climate-injury effect sizes, content contamination tended to inflate effect sizes. Further, OSHA injury reporting criteria were associated with larger safety climate-injury effect sizes than more inclusive injury operationalizations.

This study contributes to the extant safety climate literature in several ways. First, this is the only known attempt to meta-analytically examine the safety climate-injury relationship at the group level of analysis. This contributes to the safety climate literature by elucidating the relationship between safety climate and injuries at the appropriate level of analysis. Second, given the great variability observed among safety climate-injury effect sizes, this study represents the most extensive examination to date

of potential moderators of that relationship. Of note, this study represents the first attempt to quantitatively examine the effect of safety climate content contamination and deficiency on the safety climate-injury relationship. Given the number of safety climate measures in existence and the presence of extensive content variability among them, these findings suggest that greater attention should be paid to the operationalization of safety climate. It is hoped that the examination of these moderators will inspire additional research and ultimately lead to greater understanding of the relationship between safety climate and injuries.

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APPENDIX A

SAFETY CLIMATE SCALE RATING QUESTIONNAIRE

The purpose of this questionnaire is to rate a set of safety climate measures according to the degree to which they represent a commonly held definition of safety climate. Specifically, safety climate measures will be rated according to their level of deficiency and contamination in relation to the specified safety climate construct. Deficiency is the degree to which a given scale fails to represent the specified content domain (Messick, 1980) and will be rated on a seven-point Likert scale. Contamination is the degree to which a scale measures construct irrelevant content (Messick, 1980) and will be operationalized as the proportion of contaminated items within a measure. The definition of safety climate for the purpose of gauging deficiency and contamination appears below:

Definition of safety climate:

Zohar (2003) defined safety climate as the shared perception of the policies, practices, and procedures pertaining to safety. According to Zohar and Luria (2005), *safety policies* define strategic safety goals and the means for their achievement while *safety procedures* provide planned courses of action relating to those goals. Safety policies and procedures both exist at the organizational-level and are maintained by upper management (Zohar & Luria, 2005). *Safety practices* refer to the implementation of policies and procedures at the workgroup level (Zohar & Luria, 2005).

Rating scales:

Deficiency To what degree is this scale deficient as a measure of the specified safety climate domain? 7 = Completely 6 = Almost completely 5 = Significantly 4 = Moderately 3 = Somewhat 2 = Hardly 1 = Not at all	**Instructions**: A. Carefully read through all of the items in each safety climate scale. B. Determine the degree to which the scales are deficient with relation to the definition above and write your 1-7 rating in the space provided. C. Determine how many items are contaminated relative to the above definition; list the number of contaminated items in the space provided.
Contamination Given the definition of safety climate, how many items in this scale are contaminated?	

APPENDIX B

STUDIES IN COMMON WITH CLARKE (2006a)

Barling, Loughlin, & Kelloway, 2002
Clarke, 2006b
Goldenhar, Williams, & Swanson, 2003
Hayes, Perander, Smecko, & Trask, 1998
Hofmann, & Stetzer, 1996
Huang, Ho, Smith, & Chen, 2006
Mearns, Flin, Gordon, & Fleming, 1998
Mearns, Whitaker, & Flin, 2003
Michael, Evans, Jansen, & Haight, 2005
Probst, 2004
Siu, Phillips, & Leung, 2004
Williamson, Feyer, Cairns, & Biancotti, 1997
Zacharatos, Barling, & Iverson, 2005
Zohar, 2000
Zohar, 2002
Zohar, & Luria, 2004

STUDIES IN COMMON WITH NAHRGHANG ET AL. (2007)

Baas, 2002
Barling, Loughlin, & Kelloway, 2002
Goldenhar, Williams, & Swanson, 2003
Grosch, Gershon, Murphy, & DeJoy, 1999
Gyekye, 2005
Hayes, Perander, Smecko, & Trask, 1998
Hofmann, & Stetzer, 1996
Katz-Novan, Naveh, & Stern, 2005
Krispin, 1999
Mearns, Whitaker, & Flin, 2003
Michael, Evans, Jansen, & Haight, 2005
Probst, 2004
Siu, Phillips, & Leung, 2004
Vitro, 1991
Zacharatos, Barling, & Iverson, 2005
Zohar, 2000
Zohar, 2002
Zohar, & Luria, 2004

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