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4 authors:

Michael S. Christian
University of North Carolina at Chapel Hill

Jill C. Bradley-Geist
California State University, Fresno

Craig Wallace
Oklahoma State University - Stillwater

Michael Burke
Tulane University

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Workplace Safety: A Meta-Analysis of the Roles of Person and Situation Factors

Michael S. Christian
University of Arizona

Jill C. Bradley
California State University, Fresno

J. Craig Wallace
Oklahoma State University

Michael J. Burke
Tulane University

Recent conceptual and methodological advances in behavioral safety research afford an opportunity to integrate past and recent research findings. Building on theoretical models of worker performance and work climate, this study quantitatively integrates the safety literature by meta-analytically examining person- and situation-based antecedents of safety performance behaviors and safety outcomes (i.e., accidents and injuries). As anticipated, safety knowledge and safety motivation were most strongly related to safety performance behaviors, closely followed by psychological safety climate and group safety climate. With regard to accidents and injuries, however, group safety climate had the strongest association. In addition, tests of a meta-analytic path model provided support for the theoretical model that guided this overall investigation. The implications of these findings for advancing the study and management of workplace safety are discussed.

Keywords: occupational safety, safety performance, accidents, safety climate, Occupational Safety and Health Administration

Thousands of deaths and disabilities occur because of occupational accidents each year in the United States, including 5,804 work-related fatalities and 4.1 million nonfatal occupational injuries and illnesses in 2006 (Bureau of Labor Statistics, U.S. Department of Labor, 2007). Given these statistics, researchers have devoted much effort to studying workplace safety. Although an impressive quantity of information has resulted, much of the behaviorally oriented occupational safety research is plagued by lack of theory, weak methodology, and unclear conceptualizations of constructs. Moreover, studies of antecedents to safety have tended to focus on either individual differences or contextual factors but rarely on both. Additionally, though previous studies have summarized aspects of this literature (Clarke, 2006a; Clarke & Robertson, 2005), these efforts have not integrated the array of situational and individual antecedents to safety nor have they attended to levels-of-analysis issues that have implications for the interpretation of findings.

Hence, we have four goals for the current study. First, we illustrate the benefits of developing clear operationalizations of safety constructs. Second, we build on existing theory and research (e.g., Campbell, McCloy, Oppler, & Sager, 1993; Neal & Griffin, 2004) by detailing a conceptual framework with which to organize and study relationships between antecedents and safety criteria. To this end, we organize constructs to develop a parsimonious description of the person- and situation-related antecedents of workplace safety. Third, using this conceptual framework, we meta-analytically estimate hypothesized relationships. Fourth, we use meta-analytic path modeling to test an exemplar model of the integrated conceptual framework.

Conceptualizing Workplace Safety

One shortcoming in the safety literature is a lack of clear and consistent construct definitions and conceptualizations, both on the predictor and criterion sides (cf. Clarke & Robertson, 2005). As a result, inconsistencies exist between studies, and empirical findings do not always align with theoretical predictions. Although there have been efforts to overcome this situation in particular domains (e.g., safety climate; Flin, Mearns, O'Connor, & Bryden, 2000), no study has comprehensively addressed such deficiencies. Clear delineation of constructs is a critical step to facilitate not only the organization of accumulated knowledge, but also the development of theory in the safety domain. Thus, we begin by clarifying conceptualizations of safety criteria before presenting a model for classifying and understanding their antecedents.

Michael S. Christian, Eller College of Management, University of Arizona; Jill C. Bradley, Craig School of Business, California State University, Fresno; J. Craig Wallace, William S. Spears School of Business, Oklahoma State University; Michael J. Burke, A. B. Freeman School of Business, Tulane University.

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Correspondence concerning this article should be addressed to Michael S. Christian, Eller College of Management, University of Arizona, Department of Management and Organizations, McClelland Hall, P.O. Box 210108, Tucson, AZ 85721-0108. E-mail: msc@email.arizona.edu

Problematically, the term *safety performance* may be used to refer to two different concepts. At times, safety performance might refer to an organizational metric for safety outcomes, such as number of injuries per year. Conversely, safety performance may refer to a metric for safety-related behaviors of individuals (e.g., Burke, Sarpy, Tesluk, & Smith-Crowe, 2002; Neal & Griffin, 2004). Distinguishing safety-related behaviors from the outcomes of those behaviors is important, because each might have differential relationships with antecedents. Thus, we consider safety performance behaviors and safety outcomes to be distinct. In contrast to safety performance behaviors, safety outcomes are tangible events or results, such as accidents, injuries, or fatalities.

Conceptualizing safety performance as individual behaviors provides researchers with a measurable criterion, which is more proximally related to psychological factors than accidents or injuries. Safety performance behaviors can be predicted with greater accuracy than outcomes, which often have a low base rate and skewed distributions (cf. Zohar, 2000). Similar to job performance in general, safety performance behaviors can be scaled by the frequency with which employees engage in the behaviors and are distinguishable in terms of their antecedents and covariation with safety outcomes (Burke, Sarpy, et al., 2002). However, although safety performance is conceptually similar to job performance in general, it does not fit neatly into task, contextual, or adaptive performance and thus should be treated as a separate domain of job performance (Burke, Sarpy, et al., 2002; Parker & Turner, 2002).

Several conceptual models of safety performance have been advanced. The model of safety performance outlined by Burke, Sarpy, et al. (2002)—defined as "actions or behaviors that individuals exhibit in almost all jobs to promote the health and safety of workers, clients, the public, and the environment" (p. 432)—includes four factors: (a) using personal protective equipment, (b) engaging in work practice to reduce risk, (c) communicating hazards and accidents, and (d) exercising employee rights and responsibilities. Although the factors are distinct (but correlated), Burke, Sarpy, et al. suggested that under certain conditions, using the aggregate of the four factors is appropriate. Other conceptualizations of safety performance distinguish between safety "compliance" and safety "participation," with the former referring to "generally mandated" safety behaviors and the latter referring to safety behaviors that are "frequently voluntary" (Neal, Griffin, & Hart, 2000, p. 101). This distinction is similar to that between task and contextual performance in the job performance literature (e.g., Borman & Motowidlo, 1993).

Predicting Safety Criteria: A Conceptual Model

To develop a model of the processes through which situations and individual difference factors influence safety performance behaviors and outcomes, we build upon Neal and Griffin's (2004) model of workplace safety. This model is grounded in Campbell et al.'s (1993) theory of performance, which identifies three proximal determinants of an individual's performance—knowledge, skills, and motivation to perform—and suggests that distal antecedents of performance (e.g., training, organizational climate, personality) presumably influence performance through increases in these proximal determinants.[1] Hence, Neal and Griffin posited that antecedents like safety climate or personality directly influence safety motivation and knowledge, which in turn directly influence safety performance behaviors, which then directly relate to safety outcomes, such as accidents and injuries. We used a modified version of Neal and Griffin's framework for organizing the literature and studying construct relations (see Figure 1). Accordingly, we posit that situational factors, individual differences, and attitudes are distal in their relationships with safety performance and are even more distally related to safety outcomes. These factors are expected to impact more proximal states or self-regulatory processes that directly affect safety performance behaviors. Of importance, this theoretical framework informs not only the magnitudes of the relationships we expected to observe between various antecedents and safety criteria but also the processes through which workplace accidents and injuries occur.

Antecedents of Safety Performance and Safety Outcomes

At the broadest level, we classified antecedents as *person related* or *situation related*; within each of these areas, we identified more proximal and more distal antecedents to safety performance behaviors (see Figure 1). We considered safety knowledge and safety motivation proximal antecedents to safety performance behaviors. In contrast, situation-related factors and individual dispositional characteristics and attitudes were considered to be more distal. With regard to safety outcomes, all of the antecedents are indirect in that they operate through safety performance behaviors. The only direct antecedent to safety outcomes in the theoretical model is safety performance behavior. However, for consistency, we refer to the antecedents as either *distal* or *proximal,* indicating relative distance from either criterion.

As a general rule, proximal factors were anticipated to yield larger relationships than distal factors. Further, where theoretically relevant, we distinguish between *safety compliance* and *safety participation* (Neal & Griffin, 2004). Consistent with research on task versus contextual performance in the general organizational literature, Griffin and Neal (2000) found that safety motivation was more strongly related to safety participation than safety knowledge, whereas the converse was true for safety compliance. We likewise anticipate that motivation should play a larger role in discretionary safety participation behaviors, whereas knowledge should be more related to compulsory safety compliance.

Person Related: Proximal Antecedents

Safety knowledge was the first proximal person-related factor. In line with our conceptual model, we anticipated that knowledge would have a strong positive relationship with safety performance because knowledge is a direct determinant of performance behaviors. In short, knowing how to perform safely (e.g., handling hazardous chemicals, emergency procedures) is a precondition to enacting safe behaviors. Thus, safety knowledge should be strongly related to safety performance behaviors. Furthermore,

[1] Kanfer (1990, 1992) proposed that distal traits relate to performance and outcomes through proximal statelike individual differences and self-regulatory processes. A great deal of empirical support has been gleaned for this motivational process as well (e.g., Barrick et al., 1993; Bergman, Donovan, Drasgow, Overton, & Henning, 2008; Chen, Casper, & Cortina, 2001; Chen, Gully, Whiteman, & Kilcullen, 2000), even in the safety literature (e.g., Wallace & Chen, 2006).

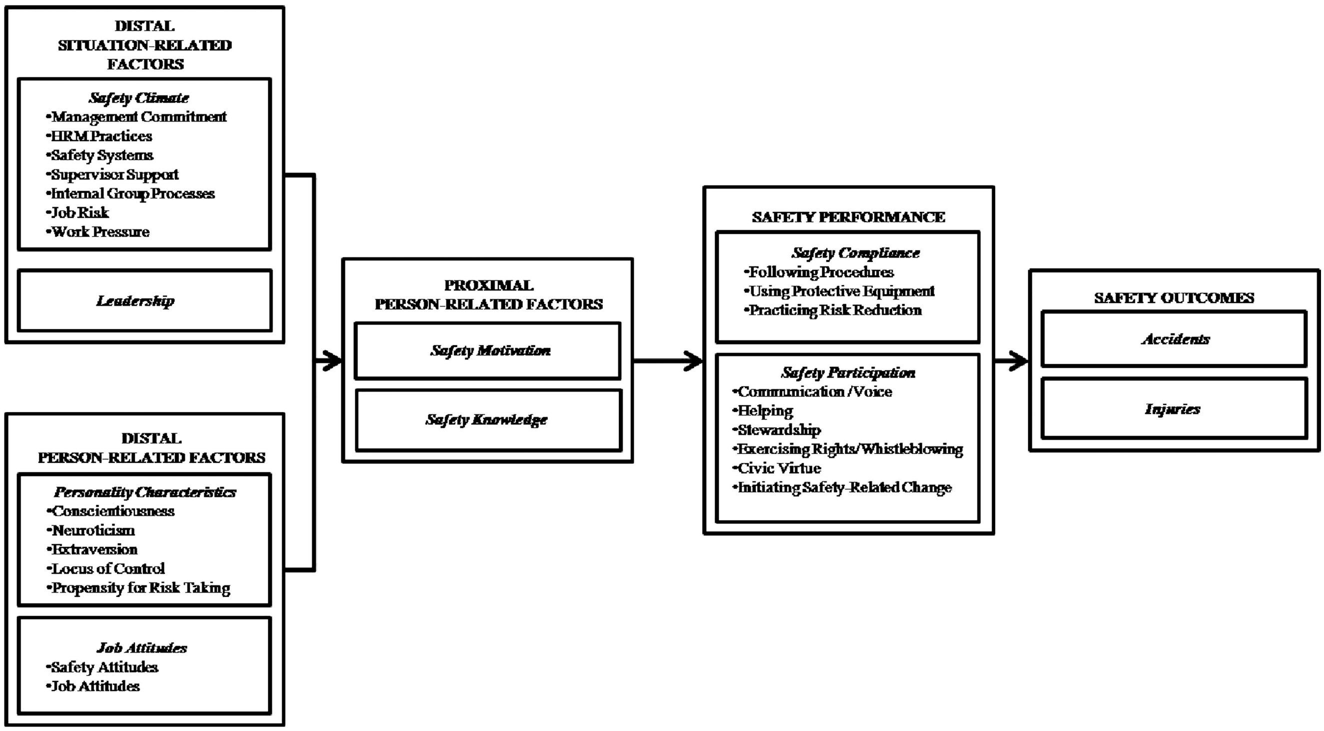

Figure 1. An integrative model of workplace safety.

safety knowledge should exhibit higher correlations with safety compliance than with safety motivation (cf. Griffin & Neal, 2000). For safety outcomes, we expected moderate negative relationships, because knowledge effects should operate through safety performance behaviors.

Safety motivation was another direct person-related antecedent of safety performance behaviors. Safety motivation reflects "an individual's willingness to exert effort to enact safety behaviors and the valence associated with those behaviors" (Neal & Griffin, 2006, p. 947). For the same reasons identified for safety knowledge, we expected safety motivation to be strongly related to safety performance and moderately related to fewer accidents and injuries. Given the motivation-related conceptualization of safety participation, we expected safety motivation would be more strongly related to safety participation than safety compliance.

Person Related: Distal Antecedents

With a few exceptions, we used the Big Five framework (e.g., Costa & McCrae, 1985) to organize dispositional traits. As noted by Clarke and Robertson (2005) in their meta-analysis of personality and accidents, the Big Five is useful for providing order to a disordered literature. Still, the occupational safety literature contains too few studies of openness to experience and agreeableness to consider in a cumulative investigation.

Conscientiousness comprises both achievement and responsibility (dependability) components (Hough, 1992). Conscientious individuals are more likely to set, commit to, and strive for personal goals; they also are more dependable and responsible than less conscientious individuals. Further, conscientiousness is positively related to motivation (Furnham, Petrides, Jackson, & Cotter, 2002). Thus, because conscientiousness and safety motivation should be positively related (e.g., Griffin, Burley, & Neal, 2000), we anticipated that conscientiousness would indirectly relate to safety performance behaviors, particularly those that are voluntary (i.e., safety participation). Because of the distal relationship between conscientiousness and safety outcomes, we anticipated a weak negative or equivocal relationship between conscientiousness and accidents and injuries, as indicated by Clarke and Robertson's (2005) meta-analysis.

People high in *neuroticism* may have difficulty coping with threatening situations (cf. Hobfoll, 1989; Kanfer & Ackerman, 1989), in part because they may devote more resources to worry and anxiety as opposed to the task at hand. Additionally, neuroticism is negatively related to intrinsic motivation (Furnham et al., 2002) and the desire to take control over one's environment (Judge, 1993), both of which likely hamper safety performance. On the other hand, given their vigilance toward negative stimuli in the environment, people high in neuroticism may be attuned to signs of danger in the workplace (Mathews & MacLeod, 1985). Further, in their meta-analysis, Clarke and Robertson (2005) found that neuroticism had a negligible relationship with accidents. Thus, we expected a weak negative correlation with safety performance behaviors and an even weaker positive association with accidents and injuries.

Extraversion was anticipated to be only weakly or equivocally related to safety performance behaviors or safety outcomes. On the one hand, high extraversion could be detrimental because the sensation-seeking aspect of the trait could lead people to engage in risky behavior (e.g., Golimbet, Alfimova, Gritsenko, & Ebstein, 2007). On the other hand, extraversion is closely aligned with positive affect (Eysenck, 1967; Iverson & Erwin, 1997), which is associated with high self-efficacy (Judge, 1993) and contextually oriented behaviors. Moreover, extraversion has been found to be unrelated to accidents (e.g., Clarke & Robertson, 2005).

Locus of control is the extent to which people feel they personally control the events in their lives as opposed to those events being controlled by the external environment (cf. Judge, Erez, Bono, & Thoresen, 2002). The Big Five trait most strongly related to locus of control appears to be neuroticism (Judge & Bono, 2001). However, given that over half of the variance in locus of control cannot be explained by neuroticism, we examined these two categories separately. People who believe they can control events should be more motivated to learn about and engage in safe practices than people who do not believe they can control accidents. Given its distal relationship with criteria, we anticipated a moderate relationship between internal locus of control and safety performance behaviors (particularly safety participation due to the motivational component inherent in locus of control) and a weaker relationship with outcomes.

Propensity for risk taking has been described as an amalgamation of several Big Five traits (Nicholson, Soane, Fenton-O'Creevy, & Willman, 2005). People high in risk taking tend to be impulsive sensation seekers (Zuckerman, Kuhlman, Thornquist, & Kiers, 1991), who might be more apt than their coworkers to engage in unsafe behaviors either because they underestimate the chances of accidents or because they are actually stimulated by risk. Thus, we expected risk taking to have a negative relationship with safety performance and a positive relationship with safety outcomes. Further, we predicted risk taking to be moderately related to safety performance and weakly related to outcomes because of its distal relationship with the criteria in the theoretical model.

Attitudes, unlike personality, are presumably fluid and susceptible to change depending on the situation (e.g., Petty & Cacioppo, 1986). Here, we examine general *job attitudes* that people hold about their work (i.e., job satisfaction and organizational commitment). In theory, more positive attitudes might lead to greater motivation to behave safely. However, given research suggesting that attitudes are a distal and imperfect predictor of behavior (e.g., Fazio & Williams, 1986) and the equivocal findings linking job attitudes with performance (cf. Judge, Thoresen, Bono, & Patton, 2001), we do not offer firm predictions.

Situation Related: Safety Climate

A recent meta-analysis by Clarke (2006a) demonstrated that safety climate is a meaningful predictor of safety performance behaviors (particularly safety participation) and is weakly related to accidents. In the current study, we build on Clarke's findings by further differentiating safety climate into psychological safety climate and group safety climate. We define psychological safety climate as individual perceptions of safety-related policies, practices, and procedures pertaining to safety matters that affect personal well-being at work (cf. L. A. James & James, 1989; L. R. James, Hater, Gent, & Bruni, 1978; L. R. James & Sells, 1981). When these perceptions are shared among individuals in a particular work environment, a group-level climate emerges (L. R. James, James, & Ashe, 1990). Thus, we define group-level safety climate as shared perceptions of work environment characteristics as they pertain to safety matters that affect a group of individuals (e.g., Neal & Griffin, 2004; Zohar & Luria, 2005).

Further, we view safety climate as having a hierarchical structure at both the psychological and group levels, on the basis of theoretical arguments and the confirmatory factor analytic work of L. A. James and James (1989) and Burke, Borucki, and Hurley (1992). At the higher order factor level, we conceptualize psychological climate with respect to employees' perceptions of well-being. That is, at the higher order factor level, we view first-order climate factors as driven by an employee's emotional evaluation of the degree to which the work environment is perceived as personally beneficial or detrimental. In fact, Griffin and Neal's (2000) factor analytic and path modeling research, which involved a higher order safety climate factor, relied directly on L. A. James and James (1989) and Burke et al.'s (1992) arguments in positing and confirming that safety climate is driven by a singular, higher order factor reflecting assessments of well-being. When this perception is aggregated to the group level, or when the perception refers to the degree to which the work environment is beneficial or detrimental to the group as a whole, this higher order factor is conceptually a group-level factor (e.g., L. R. James et al., 2008).

Safety climate was expected to positively influence safety performance behaviors (through safety knowledge and motivation) and to negatively influence outcomes. A positive safety climate should encourage safe action either through reward or through principles of social exchange (cf. Clarke, 2006a; Griffin & Neal, 2000; Hofmann, Morgeson, & Gerras, 2003; Zohar, 2000). Further, positive safety climates should enhance safety knowledge because they are reflective of environments where safety information is communicated formally through training and meetings and informally through on-the-job discussion. Thus, we anticipated that safety climate would be moderately related to safety performance behaviors and weakly related to more distal safety outcomes. We further anticipated that safety climate would be more strongly related to safety participation than safety compliance, because of the voluntary nature of participation and the motivational desire of employees to reciprocate manager actions regarding safety (e.g., Clarke, 2006a; Hofmann et al., 2003). We also expected that group-level climate would have stronger relationships with safety performance and outcomes than psychological climate. Zohar (e.g., 2000) has argued that group-level climate results from patterns of behaviors and practices as opposed to isolated events or environmental circumstances. For perceptions to be shared among individuals, an objective reality in the external environment must be concrete and influential enough that people can agree in their perceptions.

To examine specific facets of safety climate, we utilized the taxonomy put forth by Neal and Griffin (2004). As shown in Table 1, included within this taxonomy are the following: management commitment, human resources management practices, safety systems, supervisory support, internal group processes, boundary management (for which we found no relevant studies),

Table 1
First-Order Factors of Safety Climate

Factor	Element	Example
Management commitment	The extent to which people perceive that management values safety and engages in communication and actions that support safety	Perceived organizational support, management safety practices and/or values, managerial communication of safety
Human resource management practices	The extent to which people perceive that selection, training, and reward systems contribute to safety	Selection systems, safety training, performance management, reward systems
Safety systems	Perceived quality of policies, procedures, or interventions implemented by an organization with the intention of improving safety outcomes	Hazard management, incident investigations, safety policies and procedures
Supervisor support	The extent to which people believe their supervisor values safety as reflected in communication, encouragement, and consequences	Supervisor safety consciousness, supervisory safety values, supervisor safety communication, supervisory safety orientation
Internal group processes	Perceptions of communication and support for safety within work groups or the extent to which employees perceive that their coworkers provide them with safety-related cooperation and encouragement	Safety backup, safety communication, peer safety orientation, trust in peers
Boundary management	The perceived quality of communication between the work group and other relevant stakeholders regarding safety issues	N/A[a]
Risk	The extent to which workers perceive the work itself as dangerous	Perceived job risk, perceived accident potential, perceived physical hazards, perceived job safety
Work pressure	The extent to which the workload overwhelms one's ability to perform safely	Production pressure, pressure to take shortcuts, workload, time pressure, role overload

Note. Adapted from Neal and Griffin (2004).
[a] No applicable studies were found that examined the boundary management factor.

risk, and work pressure.[2] Because each first-order factor is distally related to safety behavior and outcomes, we anticipated that they would generally have moderate relationships with safety performance behavior and weaker relationships with outcomes.

Situation Related: Leadership

Leadership refers to perceptions of how a manager behaves, enacts, and achieves organizational or group objectives in general (as compared with the supervisor support facet of safety climate, which refers to safety-specific supervisory behaviors; cf. Zohar, 2000). We included constructs such as leader–member exchange (LMX) and transformational leadership in this category. Employees who have positive feelings toward their leader are more likely to reciprocate when possible. As such, leadership quality has been found to be related to occupational safety and safety outcomes (Hofmann et al., 2003; Hofmann & Morgeson, 1999; Zohar, 2002a; Zohar & Luria, 2003). Further, Hofmann et al. (2003) found that high-quality relationships with supervisors predicted employees' safety-related citizenship behaviors. Hence, we expected leadership to have a stronger relationship with safety participation than with compliance. However, we expected leadership to have a moderate relationship with performance and a weak relationship with accidents.

Method

Literature Search

A search was conducted to identify all peer-reviewed published articles about predictors of occupational safety performance and outcomes. Included in our definition of safety outcomes were accidents, injuries, and fatalities as well as safety performance behaviors. Keywords for the literature searches included combinations of the following: *safe(ty) climate; safe(ty) behaviors; safe(ty) performance; (workplace, organizational,* or *occupational) (injuries, accidents,* or *fatalities*). Through September 2008, we conducted electronic literature searches of databases, including PsycINFO, Social Science Citation Index, and MEDLINE. In addition, we conducted manual searches of major journals relevant to industrial–organizational psychology and occupational safety (e.g., *Academy of Management Journal*, *Journal of Applied Psychology*, *Personnel Psychology, Journal of Safety Research, Journal of Occupational Health Psychology, Accident Analysis and Prevention, Safety Science*) to locate articles that did not surface in the database searches. We also consulted reference sections of recent review articles to identify additional studies

[2] Many of our first-order climate factors (i.e., first-order climate factors coming from Neal & Griffin's, 2004, work) were included in Griffin and Neal's (2000) hierarchical model of safety climate (e.g., Internal Group Processes in our study overlaps with the factor they labeled Safety Communication; Management Commitment in our study was labeled as Management Values in their earlier work). Notably, our first-order climate factors, which reflect more specific content related to these work environment characteristics, are highly consistent with common first-order factors (e.g., the focus on supervision, work group processes, human resource practices, role overload, etc.) identified in several reviews of the safety climate literature (cf. Flin et al., 2000) and reviews of the general climate literature (e.g., Burke, Borucki, & Kaufman, 2002; L. R. James et al., 2008).

(e.g., Burke, Holman, & Birdi, 2006; Clarke & Robertson, 2005). The initial searches yielded over 500 potential articles.

Criteria for Inclusion

After collecting the articles, two researchers independently assessed each study to determine that (a) the study reported an effect size between one or more antecedent and one or more safety outcome, (b) the outcome occurred on the job, and (c) the job or outcome was not driving related. We excluded driving outcomes because many studies of driving safety confound work-related driving with personal-use driving. Moreover, evidence suggests differences in the antecedents of driving accidents versus other workplace accidents (Iversen & Rundmo, 2002; Lajunen, 2001; Wagenaar, 1992). After independent evaluation, agreement about study inclusion was near 100%, and the researchers resolved several discrepancies through discussion. At the end of the process, 90 studies and 1,744 effect sizes had been identified for the meta-analysis, 477 of which were utilized in the predictor-criterion analyses.

Categorization of Criterion Variables

To categorize criterion variables, two independent raters sorted them into the predetermined safety criterion categories described next. After both raters categorized each effect, the results were compared to establish agreement, initially estimated at 94%. All discrepancies were resolved through discussion, resulting in 100% agreement.

Safety outcomes: Accidents and injuries. Accidents and injuries are often treated interchangeably with regard to their predictors (e.g., Cooper, Phillips, Sutherland, & Makin, 1994; Sulzer-Azaroff, Loafman, Merante, & Hlavacek, 1990; Tuncel, Lotlikar, Salem, & Daraiseh, 2006). Moreover, definitions of accidents are often confounded with injuries, with some researchers labeling as accidents only those occurrences that result in injuries needing medical attention (cf. Visser, Ysbrand, Stolk, Neeleman, & Rosmalen, 2007). Thus, we computed an overall composite of accidents and injuries.

Safety performance. Our conceptualization of safety performance refers to individual behaviors; either measured at the individual level or aggregated (e.g., rated groups of workers). Safety performance was defined as safety compliance and safety participation (cf. Neal & Griffin, 2004). Safety-related behaviors required by the organization were classified as safety compliance. Safety participation consisted of voluntary behaviors that did not contribute to personal safety but supported safety in the larger organizational context. We augmented this definition with the six safety citizenship factors provided by Hofmann et al. (2003): communication and voice, helping, stewardship, whistle-blowing, civic virtue, and initiating safety-related change. Finally, we included a category representing a higher order safety performance factor, consistent with Burke, Sarpy, et al.'s (2002) arguments. This composite included broad, overall measures of safety-related behaviors in addition to specific task (safety compliance) and contextual (safety participation) behaviors. This composite variable is conceptually meaningful because in many types of safety-related work, contextual aspects of work, such as helping coworkers in routine and nonroutine contexts, are requisite tasks for which individuals often receive extensive training.

Categorization of Predictor Variables

We first generated a list of all predictor constructs and specific operational measures utilized in each study. From this list, two independent raters grouped together identical and conceptually similar predictors based on logic, empirical evidence, and theoretical considerations (e.g., combining neuroticism and negative affectivity, combining conscientiousness and cognitive failures, which is reflective of poor dependability; cf. Wallace & Chen, 2005). At the broadest level, predictors were sorted into person-related and situation-related factors. Within each factor, several domains were created to organize construct categories.

For person factors, the domains included proximal factors (i.e., safety knowledge, safety motivation) and distal factors (e.g., Big Five personality traits, internal locus of control, risk-taking propensity, and job attitudes). For situation factors, categories were based on whether the measure was individual level (e.g., psychological safety climate or leadership) or group level (e.g., work group or organizational safety climate).

In our categorizing of safety climate, we encountered two conceptual decisions. First, we had to clarify our conceptualization of climate with regard to its factor structure, and second we had to create a rule for how to operationalize climate at different levels of analysis. First, we conceptualized climate as a higher order overall factor in addition to a more specific set of first-order factors consistent with Neal and Griffin (2004). Thus, we created a category for overall safety climate, which included studies reporting (a) an overall composite safety climate score or (b) at least two dimensions consistent with Neal and Griffin (2004), from which we calculated a composite data point. Next, studies were grouped into each dimension of safety climate.

The second conceptual decision involved categorizing climate measures at different levels of analysis. We coded climate at two levels: individual (psychological) and group (work group, team, and organizational levels). We defined psychological climate as individual perceptions of work environment characteristics as they pertain to safety matters that affect personal well-being (cf. L. R. James et al., 1978; L. R. James & Sells, 1981), whereas group safety climate was defined as shared perceptions of the same (e.g., Neal & Griffin, 2004; Zohar & Luria, 2005) with regard to the work group or the organization. To be defined as group-level safety climate, a study must have (a) collected individual-level data and aggregated on the basis of an acceptable measure of agreement (e.g., r_{wg}, .70 or higher; Glick, 1985) or (b) collected data at the group level (e.g., supervisor ratings of safety climate). Consistent with recommendations by Ostroff and Harrison (1999), we did not include cross-level effects or nested data. Rather, we included only correlations obtained from primary studies that measured the predictor and criterion at the same levels. Table 2 illustrates the levels of analysis at which we coded constructs for each primary study.

Coding of Studies

The coding process was conducted by three researchers. Initially, the studies were divided among the researchers such that

(*text continues on page 1116*)

Table 2
Studies Included in the Meta-Analysis (N = 90 Studies)

Study	*N*	Design	Industrial sector	Sample description	Level of analysis	Coded predictor construct	Source (predictor)	Coded criterion construct	Source (criterion)
Barling et al. (2003)	16,446	Concurrent	Misc. industries	Australian employees	Individual	Job attitudes, safety systems, and work pressure	Self	Injuries	Self
Barling et al. (2002)	174	Concurrent	Food service	Misc. employees	Individual	Safety climate and leadership	Self	Accidents/injuries and safety participation	Self
	164	Concurrent	Misc. occupations, 88% service	Employees younger than 25 years old	Individual	Safety climate, leadership, and work pressure	Self	Accidents/injuries and safety participation	Self
Borofsky & Smith (1993)	53	Longitudinal	Manufacturing	Misc. employees	Individual	Safety systems	Self	Accidents	Archival
Brown et al. (2000)	551	Concurrent	Steel mills	Equipment and maintenance employees	Individual	Locus of control, risk taking behavior, safety climate, and work pressure	Self	Safety compliance	Self
Burke, Sarpy, et al. (2002)	127–133	Concurrent	Hazardous waste	Operators, technicians, electricians, engineers, handlers, plumbers, misc.	Individual	Safety knowledge	Archival	Safety performance (overall), safety compliance, and safety participation	Supervisor
Burke et al. (2008)	31	Concurrent	Health care	Misc. employees	Organizational	Safety climate	Archival	Accidents	Archival
	67	Concurrent	Health care	Misc. employees	Organizational	Safety climate	Archival	Safety performance (overall)	Archival
Burt et al. (2008)	104	Concurrent	Power generation and construction	N/A	Individual	Job attitudes	Self	Safety participation	Self
Cellar et al. (2001)	202	Concurrent	Varied	College students	Individual	Conscientiousness, extraversion, and neuroticism	Self	Accidents	Self
Clarke & Ward (2006)	83	Concurrent	Glassware manufacturing	Misc. employees	Individual	Safety climate and leadership	Self	Safety participation	Self
	22	Concurrent	Glassware manufacturing	Supervisors	Individual	Safety climate and leadership	Self	Safety participation	Self
Clarke (2006b)	109	Concurrent	UK car manufacturing	N/A	Individual	Safety climate, leadership, and work pressure	Self	Accidents and safety compliance	Self
Cooper & Phillips (2004)	540	Longitudinal	Packaging	Production employees	Individual	Safety climate	Self	Safety performance (overall)	Other
Davids & Mahoney (1957)	34	Concurrent	Industrial plants	N/A	Individual	Extraversion and neuroticism	Self	Accidents	Archival
DeJoy et al. (2004)	2,120–2,182	Concurrent	Retail stores	Retail employees	Individual	Safety climate, management commitment, leadership, internal group processes, risk, and work pressure	Self	Safety performance (overall)	Self
Donald & Canter (1994)	10	Concurrent	Chemical industry	Misc. employees	Organizational	Safety climate	Self	Accidents	Self
Dunbar (1993)	44	Concurrent	Chemical manufacturing	Emergency response	Individual	HRM practices	Self	Safety compliance	Observer

(*table continues*)

Table 2 (*continued*)

Study	*N*	Design	Industrial sector	Sample description	Level of analysis	Coded predictor construct	Source (predictor)	Coded criterion construct	Source (criterion)
Eklöf (2002)	92	Concurrent	Swedish fishermen	Swedish fishermen	Individual	Safety knowledge, locus of control, and risk	Self	Safety compliance	Self
Eklöf & Törner (2005)	92	Concurrent	Fishermen	Swedish fishermen	Individual	Safety knowledge, locus of control, risk-taking behavior, and risk	Self	Safety participation	Self
Fallon et al. (2000)	359	Concurrent	Home improvement retail organization	Sales associates	Individual	Conscientiousness	Self	Safety performance (overall)	Self
Fellner & Sulzer-Azaroff (1984)	6	Longitudinal	Paper mill	N/A	Group	Management commitment	Self	Injuries	Archival
	17	Longitudinal	Paper mill	N/A	Group	Management commitment	Archival/manipulated	Safety compliance	Observer
Frone (1998)	319	Concurrent	Part-time employees who are students	Misc. employees	Individual	Neuroticism, risk-taking behavior, job attitudes, leadership, internal group processes, risk, and work pressure	Self	Injuries	Self
Fullarton & Stokes (2007)	868	Concurrent	Industrial organizations	N/A	Individual	Safety climate	Self	Injuries	Archival
Geller et al. (1996)	328	Concurrent	Plastics manufacturing	Maintenance/operations	Individual	Conscientiousness, extraversion, locus of control, risk-taking behavior, and internal group processes	Self	Safety participation	Self
	202	Concurrent	Textile manufacturing	Maintenance/operations	Individual	Conscientiousness, extraversion, locus of control, risk-taking behavior, and internal group processes	Self	Safety participation	Self
Goldenhar et al. (2003)	408	Concurrent	Construction	Laborers in the Pacific Northwest	Individual	Neuroticism, safety climate, HRM practices, leadership, and work pressure	Self	Injuries and safety compliance	Self
Griffin & Neal (2000)	326	Concurrent	Manufacturing and mining	Australian employees	Individual	Safety knowledge, safety motivation, safety climate, and HRM practices	Self	Safety compliance and safety participation	Self
	1,264	Concurrent	Manufacturing and mining	Australian employees	Individual	Safety knowledge and safety climate	Self	Safety compliance and safety participation	Self
Hansen (1989)	362	Concurrent	Chemical industry	Production and maintenance	Individual	Neuroticism and risk	Self Archival	Accidents	Archival
								Accidents	Archival
Harrell (1990)	244	Concurrent	Professional and blue-collar jobs	Canadians	Individual	Risk and work pressure	Self	Accidents	Self

(*table continues*)

Table 2 (*continued*)

Study	N	Design	Industrial sector	Sample description	Level of analysis	Coded predictor construct	Source (predictor)	Coded criterion construct	Source (criterion)
Hayes et al. (1998)	297	Concurrent	N/A	Industrial accident victims seen by medical consulting firm	Individual	Job attitudes, management commitment, safety systems, supervisor support, internal group processes, risk, and work pressure	Self	Accidents and safety compliance	Self
	301	Concurrent	N/A	Industrial accident victims seen by medical consulting firm	Individual	Management commitment, safety systems, supervisor support, internal group processes, and risk	Self	Accidents	Self
	156	Concurrent	Utilities	Telephone line employees	Individual	Management commitment, HRM practices, safety systems, supervisor support, internal group processes, and risk	Self	Accidents and safety compliance	Self
Hemingway & Smith (1999)	252	Concurrent	Health care	Nurses	Individual	Supervisor support, internal group processes, risk, and work pressure	Self	Injuries	Self
Hofmann & Morgeson (1999)	49	Concurrent	Manufacturing	Group leaders	Individual	Management commitment and leadership	Self	Safety participation and accidents	Self and archival
Hofmann & Stetzer (1996)	21	Concurrent	Chemical processing	Management, administrative, operating core	Group	Safety climate, internal group processes, and work pressure	Self	Accidents, safety compliance, and safety participation	Archival and self
Hofmann & Stetzer (1998)	159	Concurrent	Utility worker	Outdoor utility	Group	Safety climate	Self	Safety participation	Self
	1,359	Concurrent	Utility worker	Outdoor utility	Individual	Safety climate	Self	Safety participation	Self
Hsu et al. (2008)	256	Concurrent	N/A	Japanese employees	Individual	Locus of control, management commitment, safety systems, supervisor support, and internal group processes	Self	Safety performance (overall)	Self
	295	Concurrent	N/A	Taiwanese employees	Individual	Locus of control, management commitment, safety systems, supervisor support, and internal group processes	Self	Safety performance (overall)	Self
Huang et al. (2006)	1,856	Concurrent	Manufacturing, construction, service, and transportation	N/A	Individual	Locus of control, management commitment, and HRM practices	Self	Injuries	Self
Iverson & Erwin (1997)	361–362	Concurrent	Unionized blue-collar employees	Production and assembly	Individual	Neuroticism, extraversion, leadership, internal group processes, risk, and work pressure	Self	Injuries	Archival

(*table continues*)

Table 2 (*continued*)

Study	*N*	Design	Industrial sector	Sample description	Level of analysis	Coded predictor construct	Source (predictor)	Coded criterion construct	Source (criterion)
Johnson (2007)	17	Longitudinal	Heavy manufacturing	N/A	Group	Safety climate	Self	Injuries and safety performance	Archival observer
Jones & Wuebker (1993)	280	Concurrent	Health care	Hospital employees excluding physicians	Individual	Locus of control	Self	Injuries	Self
Krause et al. (1999)	73	Longitudinal	Misc. plants	N/A	Organizational	HRM practices	Other	Injuries	Archival
Liao et al. (2001)	1,286	Concurrent	Emergency services	Firefighters, officers	Individual	Neuroticism and extraversion	Self	Injuries	Archival
Lilley et al. (2002)	367	Concurrent	Logging or silviculture	Machine operators, pruners, skid/log	Individual	Work pressure	Self	Injuries	Self
Lingard (2002)	14	Longitudinal	N/A	N/A	Individual	HRM practices	Other	Safety compliance	Other
Maierhofer et al. (2000)	218	Concurrent	Beauty	Hairstylists	Individual	Safety motivation and work pressure	Self	Safety compliance	Self
						Supervisor support	Supervisor		
McLain & Jarrell (2007)	234	Concurrent	Industrial	Misc. jobs	Individual	Safety climate, management commitment, and work pressure	Self	Safety performance (overall)	Self
Mearns et al. (2001)	722	Concurrent	Offshore oil and gas installations	Maintenance, production, catering, administration	Individual	Safety motivation and risk	Self	Accidents	Self
Mearns et al. (2003)	55	Concurrent	Offshore oil and gas installations	N/A	Group	Job attitudes and management commitment	Self	Accidents and safety compliance	Archival
	13	Concurrent	Offshore oil and gas installations	N/A	Group	Job attitudes and management commitment	Self	Accidents	Self
	40	Concurrent	Offshore oil and gas installations	N/A	Organizational	Management commitment and work pressure	Self	Accidents and safety compliance	Archival
Melamed & Oksenberg (2002)	532	Concurrent	8 industrial plants (power, metal fabrication, composite material, heavy machinery, repair)	Nonshift daytime employees	Group	Risk	Archival	Injuries	Archival
Michael et al. (2005)	641	Concurrent	Wood products manufacturing	Production employees	Individual	Job attitudes, supervisor support, and risk	Self	Injuries	Archival
Michael et al. (2006)	598	Concurrent	Wood products manufacturing	Hourly employees	Individual	Job attitudes and supervisor support	Self	Accidents and injuries	Self and archival
Mohamed (1999)	36	Concurrent	Construction	Managers	Organizational	Safety climate	Self	Safety performance (overall)	Self
Neal & Griffin (2006)	33	Longitudinal	Health care	Hospital staff	Group	Safety climate	Self	Accidents	Archival
								Safety performance (overall)	Self
	135	Longitudinal	Health care	Hospital staff	Individual	Safety motivation, neuroticism, and safety climate	Self	Safety compliance and safety participation	Self

(*table continues*)

Table 2 (*continued*)

Study	*N*	Design	Industrial sector	Sample description	Level of analysis	Coded predictor construct	Source (predictor)	Coded criterion construct	Source (criterion)
Neal et al. (2000)	525	Concurrent	Health care	Australian hospital	Individual	Safety knowledge, safety motivation, safety climate, and management commitment	Self	Safety performance (overall) and safety compliance	Self
Paul & Maiti (2007)	300	Concurrent	Mining	Coal miner	Individual	Neuroticism, risk taking behavior, and job attitudes	Self	Injuries and safety performance (overall)	Archival and supervisor
Probst (2004)	136	Concurrent	Manufacturing	Production employees	Individual	Safety knowledge and safety climate	Self	Accidents/injuries and safety compliance	Self
Probst & Brubaker (2001)	134–138	Longitudinal	Food processing	Misc.	Individual	Safety knowledge, job attitudes, and supervisor support	Self	Accidents/injuries and safety compliance	Self
Prussia et al. (2003)	121	Concurrent	Steel company	Managers/supervisors	Group	Management commitment, risk, and work pressure	Supervisor	Safety performance (overall) and safety compliance	Supervisor
Real (2008)	645	Concurrent	N/A	Production employees	Individual	Supervisor support and risk	Self	Injuries and safety performance (overall)	Self
Ringenbach & Jacobs (1995)	209	Concurrent	Nuclear power plant	Clerical, operational, supervisors	Individual	Conscientiousness, safety climate, and work pressure	Self	Injuries and safety compliance	Self
Rundmo (1994)	857–863	Concurrent	Offshore petroleum	Norwegian	Individual	HRM practices and safety climate	Self	Accidents	Self
Rundmo (1996)	993–1,001	Concurrent	Petroleum	Sea platform employees	Individual	Risk	Self	Safety compliance	Self
Rundmo (2000)	730	Concurrent	Fertilizer, energy, oil	Misc. employees	Individual	Neuroticism	Self	Accidents	Self
Rundmo (2001)	814	Concurrent	Agricultural, energy and petrochemical producing	Varied	Individual	Locus of control, risk, and work pressure	Self	Safety compliance	Self
Saari & Lahtela (1979)	246	Concurrent	Light metal working	Production employees	Individual	Work pressure	Other (observed by experimenter)	Accidents	Archival
Salminen & Klen (1994)	228	Concurrent	Forestry	Forestry employees	Individual	Locus of control	Self	Safety compliance	Self
Salminen et al. (1999)	185–203	Concurrent	Forestry	Forestry employees	Individual	Neuroticism, extraversion, locus of control, and risk-taking behavior	Self	Accidents	Archival
Seo et al. (2004)	620	Concurrent	Grain elevators	Nonclerical and clerical	Individual	Safety climate	Self	Accidents, safety performance (overall), and safety compliance	Self
Simard & Marchand (1994)	68	Concurrent	Manufacturing plants	Supervisors, managers	Organizational	Safety systems and supervisor support	Self	Safety compliance and safety participation	Archival and self

(*table continues*)

Table 2 (*continued*)

Study	*N*	Design	Industrial sector	Sample description	Level of analysis	Coded predictor construct	Source (predictor)	Coded criterion construct	Source (criterion)
Siu et al. (2003)	374	Concurrent	Construction	Construction work, general	Individual	Management commitment, HRM practices, supervisor support, internal group processes, and work pressure	Self	Accidents/injuries, safety compliance, and safety participation	Self
Siu et al. (2004)	374	Concurrent	Construction	Construction employees: Hong Kong	Individual	Neuroticism, job attitudes, and safety climate	Self	Accidents	Self
Smith et al. (2006)	33	Concurrent	Companies (unspecified)	Misc.	Organizational	Safety climate	Self	Injuries	Archival
Snyder et al. (2008)	253	Concurrent	Facilities department: food service, maintenance, distribution, moving, catering	Misc.	Individual	Safety climate and risk	Self	Injuries	Self
	73	Concurrent	Pipefitting	Pipefitters	Individual	Safety climate and risk	Self	Injuries	Self
Stephenson et al. (2005)	324	Concurrent	Mining	Miners	Individual	Safety systems	Assigned	Safety compliance	Self
Storeth (2007)	1,442	Concurrent	Transportation	Norwegian: administration, sales, transport	Individual	Supervisor support, risk, and work pressure	Self	Safety performance (overall)	Self
Sutherland & Cooper (1991)	554	Longitudinal	Offshore drilling and production	Misc.	Individual	Neuroticism	Self	Accidents	Self
Thoms & Venkataraman (2002)	23	Concurrent	Manufacturing	Department managers	Group	HRM practices and risk	Self Other	Accidents	Archival
Torp & Moen (2006)	436	Longitudinal	Garage	Managers and employees	Individual	Safety systems	Self	Safety compliance	Self
Trimpop et al. (2000)	778	Concurrent	Veterinary	Vet surgeons, administration, lab technicians	Individual	Job attitudes, internal group processes, and work pressure	Self	Accidents	Self
Turner et al. (2005)	334	Concurrent	Railway	Trackside	Individual	HRM practices and work pressure	Self	Safety participation	Self
Varonen & Mattila (2000)	8	Concurrent	Sawmills, plywood, parquet plants	Finnish	Organizational	Safety motivation, safety climate, and supervisor support	Self	Accidents	Archival
Varonen & Mattila (2002)	13	Concurrent	Wood processing	Misc.	Group	Safety systems	Self	Accidents	Archival
Wallace & Vodanovich (2003a)	222	Concurrent	Military	Electrical work	Individual	Conscientiousness	Self	Accidents	Self
Wallace & Vodanovich (2003b)	219	Concurrent	Production	Maintenance/assembly line	Individual	Conscientiousness	Self	Accidents and safety performance (overall)	Self

(*table continues*)

Table 2 (*continued*)

Study	N	Design	Industrial sector	Sample description	Level of analysis	Coded predictor construct	Source (predictor)	Coded criterion construct	Source (criterion)
Watson et al. (2005)	408	Concurrent	Steel manufacturing	Sheet rolling	Individual	Management commitment, leadership, internal group processes, and risk	Self	Safety compliance	Self
Wogalter et al. (1999)	79	Concurrent	Misc.	Introduction to psychology students	Individual	Safety systems	Manipulated	Safety compliance	Self
Wu et al. (2008)	920	Concurrent	University laboratories	Faculty, staff, technicians, janitorial	Individual	Safety climate and management commitment	Self	Safety participation	Self
Wuebker (1986)	120	Concurrent	Hospitality	Hotel employees	Individual	Locus of control	Self	Accidents	Archival
Zacharatos et al. (2005)	138	Concurrent	Chemical, automotive, construction	Human resources and safety directors	Organizational	HRM practices	Archival	Injuries	Archival
	189	Concurrent	Petroleum and telecommunications	Plant/field operators, technicians	Individual	Safety knowledge, safety motivation, job attitudes, safety climate, management commitment, and HRM practices	Self	Injuries and safety compliance	Self
Zohar (2000)	53	Concurrent	Metal-processing production	Fixing heavy equipment	Group	Supervisor support and risk	Self	Injuries and accidents (microaccidents)	Self
							Other		
	534	Concurrent	Metal-processing production	Fixing heavy equipment	Individual	Supervisor support, risk, and work pressure	Self	Accidents (microaccidents)	Self
Zohar (2002a)	42	Concurrent	Metal processing	Production employees	Group	Safety climate and supervisor support	Self	Injuries	Self
Zohar (2002b)	33	Concurrent	Equipment maintenance	Line workers and supervisors	Group	HRM practices	Archival/manipulated	Accidents (microaccidents)	Other
						Work pressure	Supervisor		
Zohar & Luria (2004)	42	Concurrent	Military	Infantry soldiers	Group	Safety motivation, safety climate, supervisor support, and risk	Self	Injuries	Archival
							Supervisor		
Zohar & Luria (2005)	36–401	Concurrent	Metal, food, plastics, chemical industry	Manufacturing plant employees	Group and organizational	Safety climate	Self	Safety performance (overall)	Other

Note. N = number of participants in each independent sample. Misc. = miscellaneous; N/A = study did not provide this information; HRM = human resource management; Other = rated by external observer(s).

two individuals were responsible for coding and double coding, or verifying the initial coding of each article. In instances of disagreement between the first and second coding, a third researcher also coded the study and either resolved the issue or the researchers met to arrive at a consensus through discussion. Following this process, initial agreement was 89%, and through discussion, 100% consensus was achieved.

Meta-Analytic Calculations

We used the meta-analytic procedures proposed by Raju, Burke, Normand, and Langlois (1991). Raju et al.'s procedure yields estimates of construct-level effect sizes by correcting for artifactual error (i.e., sampling error, unreliability of measures), using sample-based artifact data (i.e., reliability estimates from the primary studies) as opposed to using artifact distributions. Raju et al.'s procedures were optimally designed in the sense of estimating appropriately defined standard errors for corrected correlations when sample-based artifact values, such as a sample-based criterion reliability estimates (or assumed-fixed population reliability estimates), are incorporated into the corrections. The reader is referred to more recent discussions by Raju and Brand (2003) and Raju, Lezotte, Fearing, and Oshima (2006) on the estimation of the standard errors for individually corrected correlations with sample-based and assumed (fixed) artifact values within Raju et al.'s meta-analytic procedures. In addition, the reader is referred to Burke and Landis (2003) for the equation used to estimate the standard error of the mean corrected correlation (assuming a random effects model) used in this meta-analysis. As noted by several authors, the utilization of a random effects model results in more accurate Type I error rates and more realistic confidence intervals than does a fixed effect model (e.g., Erez, Bloom, & Wells, 1996; Overton, 1998).

When reliability information was not provided for a particular effect, we substituted the best estimate of reliability, based on the population of studies. To arrive at this estimate, sample size weighted mean reliabilities were calculated from all reported reliabilities for each construct measure within the study population. Because scale reliability estimates may vary at multiple levels (Zyphur, Kaplan, & Christian, 2008), reliabilities were estimated within level. For archival criterion data (e.g., number of accidents during the year), no corrections for unreliability were made. The estimates of reliability calculated in the current study can be found in Table 3. Across our analyses, 63% of the reliability data were sample based.

A number of the studies measured a particular construct category in multiple ways (e.g., with different safety climate measures); in these cases, composite correlations were derived with the Spearman–Brown formula (Hunter & Schmidt, 2004, pp. 454–463). Composite correlations, in comparison to a simple averaging of correlations, are advantageous in that they provide a higher level of construct validity and limit downward biasing.

Meta-Analytic Path Analysis

To provide a more comprehensive analysis of the theoretical relationships among the factors in our conceptual framework (see Figure 1), we applied path analysis techniques to our meta-analytic data to test an exemplar path model. As input, we used a correlation matrix containing corrected correlations between each variable in the model. Three decision criteria were applied in the generation of this matrix: (a) the variables must enable a strong exemplar test of the model we present in Figure 1 (i.e., they must represent some theoretically derived combination of indirect situation-related factors and person-related factors, direct factors, safety performance, and safety outcomes); (b) the variables should represent the largest possible combination of sample sizes in each cell of the matrix; and (c) the variables should all be measured at the individual level.

Once we had applied these decision rules, we settled on a model integrating conscientiousness, safety climate, safety knowledge, safety motivation, safety performance, and safety outcomes. As we have argued, conscientiousness, although presumably not related to safety knowledge, should have a direct relationship with safety motivation. Safety climate should have a direct effect on both safety motivation and safety knowledge (e.g., Griffin & Neal, 2000). Knowledge and motivation should be directly related to performance, which is directly related to safety outcomes.

The resulting input matrix consisted of 15 cells. Two cells in our matrix were empty, between (a) conscientiousness and safety

Table 3
Mean Sample-Based Reliability Estimates Used for Analyses

Construct	*k*	*N*	Mean reliability estimate
Predictor measure			
Safety knowledge	8	2,758	.784
Safety motivation	5	1,393	.845
Conscientiousness	7	1,601	.896
Neuroticism	9	3,255	.740
Extraversion	6	1,461	.741
Locus of control	7	2,307	.755
Risk taking	4	1,173	.773
Job attitudes	10	19,780	.766
Psychological safety climate	48	33,739	.794
Management commitment	9	4,352	.889
HRM practices	4	2,964	.772
Safety systems	6	17,442	.769
Supervisor support	16	8,091	.807
Internal group processes	10	4,867	.880
Perceived job risk	14	7,986	.850
Work pressure	13	4,816	.755
Group-level safety climate	14	794	.851
Management commitment	1	121	.880
HRM practices	3	129	1.000[a]
Safety systems	3	219	.851
Supervisor support	8	358	.805
Perceived job risk	1	42	.870
Work pressure	2	63	.803
Leadership	10	4,207	.796
Criterion measure			
Accidents and injuries	5	1,800	.784
Safety performance (overall)	18	6,076	.858
Safety compliance	24	7,348	.734
Safety participation	21	5,620	.790

[a] Measures of group-level HRM practices included in the analysis were all scored dichotomously (i.e., either the organization had or did not have practices in place), so predictor measures were assumed to contain no error. All estimates were conducted within level (i.e., group or individual). HRM = human resource management.

motivation and (b) conscientiousness and safety knowledge. Thus, following recommendations by Viswesvaran and Ones (1995), we used assumed corrected population values as estimates of these relationships. For the relationship between conscientiousness and knowledge, we used the sample-weighted average of the values from Colquitt, LePine, and Noe, (2000) and Mauer, Lippstreu, and Judge (2008). This value ($r_c = .00$, $N = 1{,}908$) represented a combination of declarative and procedural knowledge, which are both components of safety knowledge (Burke, Sarpy, et al., 2002). The assumed value between conscientiousness and motivation ($r_c = .20$, $N = 574$) represented a combination of goal commitment (Barrick, Mount, & Strauss, 1993), prior participation in development activities (Mauer et al., 2008), and self-efficacy (Colquitt et al., 2000). Additionally, we used the harmonic mean of all the sample sizes contained in the matrix because the harmonic mean gives much less weight to large sample sizes than the arithmetic mean and is therefore a more conservative parameter estimate (Viswesvaran & Ones, 1995). Although we report overall fit statistics, we emphasize the magnitudes of direct and indirect effects when assessing model fit.

Results

Descriptive Information

For a complete description of the constructs coded from each study, the levels of analysis for each construct, and the source of the ratings of each construct, please refer to Table 2. Also, Table 3 presents sample-weighted mean reliability coefficients computed at the construct level, using estimates of internal consistency provided by studies.

Predictor–Criterion Relationships

A corrected mean correlation (i.e., M_ρ) is statistically significant at the $p < .05$ level when its 95% confidence interval does not include zero. Unless reported otherwise, for all mean effects reported here, the confidence interval did not overlap zero. In addition, we report credibility intervals, which indicate the extent to which individual correlations varied across studies for a particular analysis distribution (Hunter & Schmitt, 2004). Specific information on these intervals and other meta-analytic findings are reported in Tables 4 and 5. In addition, we do not report corrected predictor–criterion correlations for analyses of fewer than three studies.

General expectations. We expected to find magnitudes of relationships consistent with the conceptual model in Figure 1, which posits stronger effects for proximal factors and weaker effects for distal person-related and situation-related factors. As shown in Tables 4 and 5, in general these expectations were supported with regard to safety performance, because the two proximal factors—safety knowledge and safety motivation—exhibited stronger effects for the safety performance composite ($M_\rho = .61$ and $M_\rho = .57$, respectively) than any of the distal factors (range: $M_\rho = .18–.51$). Conversely, our expectations were not supported with regard to safety outcomes, because 20 of the 22 distal factors we examined had stronger magnitudes than the $M_\rho = .11$ (*ns*) estimate we obtained for the proximal factor safety knowledge.

In the next sections, we focus on our expectations for magnitude and direction regarding each antecedent's correlation with performance and outcomes, discussing correlation magnitudes according to the guidelines provided by Cohen (1988), which suggest that an effect size between .1 and .3 be considered weak, an effect size between .3 and .5 be considered moderate, and an effect size of .5 or higher be considered strong. Further, we interpret our findings with respect to the magnitudes of each relationship with overall safety performance and outcomes. We report the findings with respect to safety participation and safety compliance only for those variables expected to exhibit differential magnitudes. Also, we omit reporting expected relationships for which we had insufficient data to generate estimates. The remaining estimates can be found in Tables 4 and 5.

Proximal person-related factors. Consistent with expectations, safety performance was strongly related to safety knowledge ($M_\rho = .61$) and safety motivation ($M_\rho = .57$). Also, we expected that safety knowledge would be more strongly related to compliance than participation, which was not supported ($M_\rho = .60$ for compliance, $M_\rho = .61$ for participation). Further, we expected safety motivation to be more strongly related to participation than compliance; however, we obtained sufficient data only for compliance ($M_\rho = .44$). Finally, although we expected a moderate relationship, safety knowledge was not significantly related to safety outcomes ($M_\rho = -.11$).

Distal person-related factors. We expected that conscientiousness, locus of control, and risk taking would be moderately correlated with safety performance and weakly correlated with safety outcomes. Expectations were partially supported for safety performance, because safety performance was moderately related to locus of control ($M_\rho = .35$) but was weakly related to conscientiousness ($M_\rho = .18$) and risk taking ($M_\rho = -.28$). We also expected that job attitudes would be weakly (or equivocally) related to safety performance, which was supported ($M_\rho = .25$). Finally, we expected locus of control to have a stronger relationship with safety participation than compliance. This was supported ($M_\rho = .25$ for compliance; $M_\rho = .43$ for participation).

With regard to our expectations for safety outcomes, we again found partial support. Conscientiousness ($M_\rho = -.26$), neuroticism ($M_\rho = .19$), locus of control ($M_\rho = -.26$), and job attitudes ($M_\rho = -.17$) were each weakly related to safety outcomes. However, extraversion ($M_\rho = -.07$) and risk taking ($M_\rho =. 20$) were not significantly related.

Distal situation-related factors. We expected that both safety climate and leadership would have moderate relationships with safety performance and weak relationships with safety outcomes. These expectations were supported for overall safety climate and safety performance, because safety climate was moderately related to safety performance at the individual level ($M_\rho = .49$) and at the group level ($M_\rho = .51$). However, our expectation to find a stronger relationship with safety performance between group-level climate and individual-level safety climate was not supported, although the effects were in the right direction. Leadership's relationship with safety performance ($M_\rho = .31$) was in line with expectations.

Regarding the first-order safety climate factors, we found support for our expectation of moderate relationships with safety performance with the exception of individual-level perceived job risk ($M_\rho = -.29$) and individual-level work pressure ($M_\rho =$

Table 4

Results for Meta-Analysis of Person- and Situation-Related Factors With Safety Performance Composite, Safety Compliance, and Safety Participation

							95% conf. int.			80% cred. int.	
Construct	k	N	M_r	SD_r	$\boldsymbol{M_\rho}$	$SE_{M\rho}$	L	U	SD_ρ	L	U
Person-related factors											
Proximal											
Safety knowledge	9	2,893	.47	.16	**.61**	.06	.50	.72	.16	.41	.81
Compliance	8	2,803	.46	.17	.60	.05	.50	.71	.14	.42	.79
Participation	4	1,815	.45	.11	.61	.08	.46	.76	.14	.42	.79
Safety motivation	5	1,393	.50	.24	**.57**	.11	.36	.78	.23	.27	.87
Compliance	4	868	.47	.15	.44	.12	.20	.68	.14	.14	.74
Distal											
Conscientiousness	5	1,317	.15	.11	**.18**	.06	.06	.28	.10	.04	.31
Locus of control	9	2,858	.28	.16	**.35**	.07	.22	.48	.19	.11	.60
Compliance	4	1,685	.19	.11	.25	.08	.10	.41	.15	.06	.44
Participation	3	622	.33	.06	.43	.04	.34	.51	—	—	—
Risk taking	4	1,173	−.23	.07	**−.28**	.04	−.37	−.19	.05	−.35	−.21
Participation	3	622	−.19	.08	−.24	.06	−.36	−.12	.06	−.31	−.16
Job attitudes	4	924	.20	.07	**.25**	.04	.16	.33	.04	.19	.30
Compliance	3	624	.24	.04	.30	.03	.25	.35	.00	—	—
Situation-related factors											
Psychological safety climate	31	15,327	.39	.18	**.49**	.05	.40	.58	.17	.24	.80
Compliance	18	6,783	.36	.19	.48	.07	.35	.61	.11	.28	.85
Participation	9	2,971	.45	.13	.59	.06	.47	.70	.17	.36	.81
Management commitment	12	5,823	.34	.18	**.40**	.05	.30	.49	.22	.19	.61
Compliance	6	1,949	.33	.13	.41	.08	.25	.57	.19	.17	.66
HRM practices	7	1,656	.31	.16	**.42**	.09	.24	.60	.23	.13	.71
Compliance	3	544	.40	.17	.57	.14	.29	.85	.24	.27	.88
Participation	3	1,034	.44	.18	.58	.16	.28	.89	.27	.24	.93
Safety systems	8	2,032	.31	.16	**.38**	.07	.25	.51	.18	.15	.60
Compliance	5	1,292	.22	.11	.27	.05	.16	.38	.10	.14	.40
Supervisor support	9	3,821	.30	.11	**.38**	.06	.28	.49	.16	.18	.59
Compliance	6	1,591	.32	.14	.43	.09	.26	.60	.20	.17	.68
Internal group processes	9	4,497	.32	.12	**.40**	.05	.31	.49	.13	.24	.56
Compliance	4	1,235	.38	.07	.48	.05	.38	.59	.09	.36	.60
Participation	3	904	.42	.15	.52	.09	.34	.69	.16	.34	.69
Perceived job risk	10	7,063	−.24	.16	**−.29**	.06	−.40	−.17	.18	−.52	−.05
Compliance	6	2,764	−.13	.07	−.16	.04	−.24	−.08	.08	−.26	−.06
Work pressure	12	7,065	−.11	.10	**−.14**	.04	−.21	−.07	.11	−.28	.01
Compliance	7	2,771	−.15	.08	−.20	.04	−.28	−.12	.09	−.31	−.08
Participation	3	872	−.17	.06	−.22	.05	−.32	−.12	.04	−.27	−.16
Group-level safety climate	10	598	.43	.22	**.51**	.08	.36	.66	.24	.23	.79
Compliance	4	250	.33	.22	.40	.12	.17	.64	.21	.13	.68
Participation	3	248	.47	.25	.59	.16	.28	.90	.27	.27	.91
Management commitment	4	233	.45	.22	**.51**	.12	.27	.75	.22	.23	.79
Compliance	4	233	.45	.22	.52	.12	.28	.76	.22	.23	.81
Work pressure	3	182	−.30	.17	**−.35**	.10	−.55	−.16	.11	−.50	−.21
Compliance	3	182	−.32	.15	−.38	.09	−.56	−.21	.07	−.48	−.29
Leadership	9	3,537	.25	.09	**.31**	.04	.24	.38	.11	.19	.43
Compliance	3	925	.19	.05	.24	.03	.18	.30	.00	—	—
Participation	3	154	.30	.05	.35	.04	.27	.43	.00	—	—

Note. k = the number of independent effect sizes included in each analysis; N = sample size (for individual-level estimates, N = number of individuals; for group-level estimates, N = number of groups); M_r = mean uncorrected correlation; SD_r = standard deviation of uncorrected correlations; M_ρ = mean corrected correlation (corrected for unreliability in the predictor and criterion); $SE_{M\rho}$ = standard error of M_ρ; 95% conf. int. = 95% confidence interval for M_ρ; SD_ρ = standard deviation of estimated ρs; 80% cred. int. = 80% credibility interval; L = lower; U = upper; HRM = human resource management. Values in bold indicate mean corrected correlations for safety performance composite.

−.14). Also, we expected to find stronger effects for safety climate and leadership with safety participation than with safety compliance. As predicted, psychological safety climate was more strongly related to participation (M_ρ = .59) than compliance (M_ρ = .48), as was group-level safety climate (M_ρ = .59 for participation, M_ρ =.40 for compliance). This expectation was also supported for leadership (M_ρ = .24 for compliance, M_ρ = .35 for participation). We caution that although the magnitudes of these relationships are in the expected directions, the respective mean correlations had overlapping confidence intervals.

Table 5
Results for Meta-Analysis of Person- and Situation-Related Factors With Accidents and Injuries Composite

Construct	k	N	M_r	SD_r	M_ρ	$SE_{M\rho}$	95% conf. int. L	95% conf. int. U	SD_ρ	80% cred. int. L	80% cred. int. U
Person-related factors											
Proximal											
Safety knowledge	3	461	−.07	.14	**−.11**	.11	−.33	.12	.17	−.32	.11
Distal											
Conscientiousness	4	852	−.22	.13	**−.26**	.07	−.40	−.11	.13	−.42	−.10
Neuroticism	12	5,129	.15	.16	**.19**	.06	.08	.31	.19	−.06	.44
Extraversion	5	2,083	−.06	.10	**−.07**	.05	−.17	.04	.11	−.20	.07
Locus of control	4	2,446	−.20	.04	**−.26**	.03	−.32	−.21	.03	−.30	−.22
Risk taking	3	820	.16	.16	**.20**	.11	−.02	.41	.18	−.04	.43
Job attitudes	9	20,078	−.13	.04	**−.17**	.02	−.20	−.13	.05	−.23	−.11
Situation-related factors											
Psychological safety climate overall	27	27,639	−.11	.07	**−.14**	.02	−.17	−.11	.07	−.23	−.04
Management commitment	7	3,222	−.17	.05	**−.21**	.03	−.26	−.16	.04	−.26	−.16
HRM practices	5	3,657	−.15	.04	**−.19**	.02	−.24	−.14	.03	.02	−.16
Safety systems	6	17,439	−.12	.03	**−.16**	.01	−.19	−.13	.03	−.19	−.12
Supervisor support	12	4,615	−.12	.07	**−.15**	.03	−.20	−.10	.07	−.24	−.06
Internal group processes	8	2,839	−.16	.08	**−.19**	.03	−.25	−.12	.07	−.28	−.10
Perceived job risk	15	5,693	.15	.13	**.18**	.04	.10	.26	.15	−.02	.38
Work pressure	15	21,109	.06	.09	**.07**	.03	.01	.14	.12	−.07	.22
Group-level safety climate overall	13	421	−.34	.14	**−.39**	.05	−.48	−.29	−.44	−.33	.04
Management commitment	3	80	−.33	.07	**−.36**	.04	−.44	−.27	.00	—	—
HRM practices	3	129	−.44	.14	**−.46**	.08	−.62	−.30	.06	−.54	−.38
Safety systems	3	219	−.34	.12	**−.38**	.08	−.53	−.22	.10	−.50	−.25
Supervisor support	3	129	−.21	.06	**−.24**	.10	−.43	−.05	.03	−.28	−.20
Perceived job risk	3	118	.12	.10	**.13**	.06	.02	.25	.00	—	—
Work pressure	3	103	−.27	.15	**.33**	.11	−.54	−.11	.05	−.40	−.26
Leadership	7	1,585	−.14	.07	**−.16**	.03	−.22	−.10	.00	—	—

Note. k = the number of independent effect sizes included in each analysis; N = sample size (for individual-level estimates, N = number of individuals; for group-level estimates, N = number of groups); M_r = mean uncorrected correlation; SD_r = standard deviation of uncorrected correlations; M_ρ = mean corrected correlation (corrected for unreliability in the predictor and criterion); $SE_{M\rho}$ = standard error of M_ρ; 95% conf. int. = 95% confidence interval for M_ρ; SD_ρ = standard deviation of estimated ρ*s;* 80% cred. int. = 80% credibility interval; L = lower; U = upper; HRM = human resource management. Values in bold indicate mean corrected correlations.

Our expectations for safety climate and safety outcomes were partially supported, because overall psychological safety climate was weakly related to outcomes ($M_\rho = -.14$), as was each first-order climate factor. At the group level, we found moderate relationships for overall safety climate ($M_\rho = -.39$) and for four of the six first-order climate factors: management commitment ($M_\rho = -.36$), human resource management practices ($M_\rho = -.46$), safety systems ($M_\rho = -.38$), and work pressure ($M_\rho = .33$). Group-level supervisor support ($M_\rho = -.24$) and perceived job risk ($M_\rho = .13$) were weaker than expected. Finally, leadership, as expected, was weakly related to safety outcomes ($M_\rho = -.16$).

Moderator Analyses

To further explore our data, we conducted two sets of moderator analyses of the calculated relationships between predictors and criteria. For the sake of comprehensiveness, we present all available data regardless of k in Tables 6 and 7. However, here we present meta-analytic results only for analyses with a k of 3 or more.

Criterion source. To examine the potential effects of common method biases and other potential sources of error for which we could not correct (i.e., reporting biases), we considered criterion source as a moderator. We calculated these estimates for performance and outcomes within our two largest predictor distributions (i.e., individual- and group-level overall safety climate). Readers may refer to Table 2 for a complete list of the sources of ratings for each primary study and to Table 6 for the results of our moderator analyses. At the individual level, 92% of the safety criterion measures were self-reported, and 8% were archival or observer ratings. At the group level, 32% of the criterion measures were self-reported (aggregated to the group level), 5% were supervisor rated, and 64% were archival or rated by outside observers or authorities. For safety performance, at the individual level we were unable to find any conclusive evidence of differential correlations across criterion source, because the majority of effects were self-reported. At the group level, we again did not find conclusive evidence for moderation (i.e., no significant differences), although archival safety performance had a stronger relationship with safety climate ($M_\rho = .69$) than did self-reported safety performance ($M_\rho = .59$). For safety outcomes at the individual level, psychological safety climate was more strongly related to medical and Occupational Safety and Health Administration (OSHA) records of accidents and injuries ($M_\rho = -.20$) than to self-reported accidents and injuries ($M_\rho = -.13$), with the difference approaching significance. At the group level, the same pattern emerged, with

Table 6
Results for Moderator Analyses for Safety Climate by Criterion Source

Criterion and construct	k	N	M_r	SD_r	M_ρ	$SE_{M\rho}$ or SE_ρ	95% conf. int. L	95% conf. int. U	SD_ρ	80% cred. int. L	80% cred. int. U
Safety performance											
Psychological safety climate											
Self-reported safety behaviors	30	14,787	.38	.17	**.47**	.01	.45	.49	.43	.24	.51
Archival/observer ratings	1	540	.79	—	**.88**	.02	.85	.91	—	—	—
Group-level safety climate											
Self-reported safety behaviors	5	317	.48	.19	**.59**	.05	.49	.69	.03	.55	.63
Supervisor-rated safety behavior	1	121	.27	—	**.35**	.11	.14	.56	—	—	—
Archival/observer ratings	3	93	.63	.15	**.69**	.06	.57	.81	.65	.03	.73
Accidents/injuries											
Psychological safety climate											
Self-reported accidents/injuries	24	25,768	−.10	.06	**−.13**	.01	−.15	−.11	−.17	−.09	.03
Medical records/OSHA	4	1,920	−.16	.09	**−.20**	.03	−.26	−.14	−.24	−.16	.03
Group-level safety climate											
Self-reported accidents/injuries	2	63	−.19	.14	**−.21**	.12	−.45	.03	—	—	—
Medical records/OSHA	11	360	−.37	.14	**−.42**	.05	−.52	−.33	−.46	−.38	.03

Note. k = the number of independent effect sizes included in each analysis; N = sample size (for individual-level estimates, N = number of individuals; for group-level estimates, N = number of groups); M_r = mean uncorrected correlation; SD_r = standard deviation of uncorrected correlations; M_ρ = mean corrected correlation (corrected for unreliability in the predictor and criterion); $SE_{M\rho}$ = standard error of M_ρ; 95% conf. int. = 95% confidence interval for ρ or M_ρ; SD_ρ = standard deviation of estimated ρ*s*; 80% cred. int. = 80% credibility interval; L = lower; U = upper; OSHA = Occupational Safety and Health Administration. Values in bold indicate mean corrected correlations. Estimates of individual, disattenuated correlations were estimated with Equation 2 of Raju, Burke, Normand, and Langlois (1991), and the standard errors for these disattenuated correlations were estimated with either Equation 5 or Equation 9 of Raju and Brand (2003), depending on the availability of sample-based reliability on the predictor or criterion measure. For use of Raju et al.'s Equation 2 and Raju and Brand's Equations 5 and 9, the range restriction factor was fixed at 1.0.

medical records and OSHA records of accidents and injuries moderately related to climate ($M_\rho = -.42$), whereas self-reported outcomes were weak ($M_\rho = -.21$).

Level of analysis. Next, we investigated the extent to which operationalizing constructs at different levels of analysis (i.e., individual, work group, or organization level) moderates the relationship between climate and criteria. As depicted in Table 7, for safety performance, individual-level measures and group-level measures had similar magnitudes ($M_\rho = .49$). Organizational-level measures were weaker ($M_\rho = .38$), although the difference was not significant. For safety outcomes, we found a significant difference between individual-level measures and higher levels of analysis. Specifically, psychological safety climate ($M_\rho = -.14$) was weaker than work group safety climate ($M_\rho = -.38$) and organizational safety climate ($M_\rho = -.39$).

Relationships Among Criteria

We also conducted meta-analyses to determine the extent to which each of the criterion types included in our analyses were

Table 7
Results for Moderator Analyses for Safety Climate by Level of Analysis

Criterion and construct	k	N	M_r	SD_r	M_ρ	$SE_{M\rho}$	95% conf. int. L	95% conf. int. U	SD_ρ	80% cred. int. L	80% cred. int. U
Safety performance											
Psychological safety climate	31	15,327	.39	.18	**.49**	.05	.40	.58	.17	.24	.80
Work group-level safety climate	6	752	.43	.03	**.49**	.03	.43	.55	.18	.45	.53
Organization-level safety climate	5	247	.34	.21	**.38**	.06	.26	.50	.22	.34	.42
Accidents and injuries											
Psychological safety climate	27	27,639	−.11	.07	**−.14**	.02	−.17	−.11	.07	−.23	−.04
Work group-level safety climate	7	231	−.33	.16	**−.38**	.06	−.51	−.26	−.43	−.34	.03
Organization-level safety climate	6	190	−.34	.12	**−.39**	.07	−.52	−.26	−.43	−.35	.03

Note. k = the number of independent effect sizes included in each analysis; N = sample size (for individual-level estimates, N = number of individuals; for group-level estimates, N = number of groups); M_r = mean uncorrected correlation; SD_r = standard deviation of uncorrected correlations; M_ρ = mean corrected correlation (corrected for unreliability in the predictor and criterion); $SE_{M\rho}$ = standard error of M_ρ; 95% conf. int. = 95% confidence interval for M_ρ; SD_ρ = standard deviation of estimated ρ*s;* 80% cred. int. = 80% credibility interval; L = lower; U = upper. Values in bold indicate mean corrected correlations. Because of nonindependence of group- and organization-level effects within some primary studies, the values in this table may not add up to the totals in Tables 3 and 4.

correlated. As shown in Table 8, the safety performance composite was strongly related to safety compliance (M_ρ = .63) and safety participation (M_ρ = .80). Safety participation was moderately related to safety compliance (M_ρ = .46). The accident and injuries composite was more strongly correlated with the safety performance composite (M_ρ = −.31) than with safety participation (M_ρ = −.15) and safety compliance (M_ρ = −.14).

Exemplar Path Model

Table 9 presents the meta-analyzed individual-level correlations among the variables in the exemplar path model. We sequentially tested two nested models, inputting the harmonic mean sample size of 1,092. We first tested a full-mediation model in which conscientiousness and safety climate were exogenous and safety knowledge and safety motivation were endogenous mediators, which were directly related to safety performance. Safety performance was, in turn, directly related to accidents and injuries. Although the path coefficients were significant, this model (Model 1) fit the data only moderately well, $\chi^2(9)$ = 622.5, $p < .001$; CFI = .68; GFI = .86. On closer inspection of our data and modification indices, we determined that a more accurate theoretical model would include a path between safety motivation and safety knowledge. Theoretically, safety motivation should lead to safety knowledge acquisition. Indeed, motivation has been linked to learning outcomes and knowledge in many domains (see Colquitt et al., 2000). Thus, we tested a second full mediation model (Model 2), depicted in Figure 2, by freeing the path between safety motivation and safety knowledge. This model showed an acceptable fit to the data, $\chi^2(8)$ = 313.5, $p < .001$; CFI = .90; GFI = .94. In addition, as shown in Figure 2, all direct paths were significant ($p < .001$), providing further support for the full mediation model. Although modification indices indicated that freeing additional paths could improve overall model fit, we retained the fully mediated model because of its good fit and our desire for parsimony. Also, in Table 10, we report the direct, indirect, and total effects for the relationships in Model 2. Notably, a majority of the indirect effects are moderate to large, adding further support.

Discussion

Consistent with the theoretical framework in Figure 1, variables that are more proximally related tended to be more highly correlated than more distally related variables. Together, the overall pattern of meta-analytic correlations and path-modeling results demonstrated support for the veracity of this theoretical framework. In the best fitting path model, safety climate was positively related to both safety knowledge and safety motivation, whereas conscientiousness was positively associated with just safety motivation. Safety motivation was related to safety knowledge, and both of these variables were positively related with safety performance. In turn, safety performance was correlated with accidents and injuries. Although we were limited in our ability to run multiple iterations of the path model or to test all variables, we believe the model should hold for the other distal antecedents, because the magnitudes of the meta-analytic correlations observed exhibit the patterns expected from the theoretical model. Given the support for our exemplar path model and the overall pattern of meta-analytic correlations, we expect that situation-based factors (e.g., safety climate and leadership) and indirect person-based factors (e.g., job attitudes and personality) should influence safety performance behaviors indirectly by way of safety knowledge and safety motivation and that safety performance behaviors, in turn, influence accidents and injuries. Later, we discuss more specific findings in relation to safety outcomes, followed by discussions of future research and practice directions.

In terms of safety compliance versus safety participation, we observed that safety climate tended to be more highly related to safety participation than safety compliance. Because workers must by definition comply with obligatory or mandatory practices and procedures, safety climate should not matter as much as for behaviors that are compulsory. Consistent with this point, leaders are likely to have a stronger influence on workers' safety participation than safety compliance, which was supported in this meta-analysis. In effect, the importance that leaders place on safety likely undergirds the climate for safety and has a critical influence on discretionary safety behaviors.

Turning to safety climate and levels of analysis, we found that group and organizational safety climate generally had stronger relationships with safety performance than psychological safety climate. Psychological safety climate, by nature of its assessment from the individual person's perspective, is influenced by unique nuances of the person. In contrast, because group and organizational safety climate are shared perceptions of individuals, climate

Table 8
Meta-Analysis of Relationships Between Safety Criteria

	Safety compliance		Safety participation		Safety performance composite	
Variable	M_r, M_ρ (95% CI)	SD_ρ ($SE_{M\rho}$)	M_r, M_ρ (95% CI)	SD_ρ ($SE_{M\rho}$)	M_r, M_ρ (95% CI)	SD_ρ ($SE_{M\rho}$)
Safety compliance	— (—)	— (—)				
k, N	—	—				
Safety participation	.32, **.46** (.26, .66)	.17 (.10)	— (—)	— (—)		
k, N	5	2,909	—	—		
Safety performance composite	.38, **.63** (.60, .66)	.00 (.00)	.57, **.80** (.70, .88)	.05 (.08)	— (—)	— (—)
k, N	1	1,264	3	1,448	—	—
Accidents and injuries	−.11, **−.14** (−.20, −.08)	.07 (.03)	−.12, **−.15** (−.18, −.13)	.03 (.01)	−.25, **−.31** (−.54, −.31)	.28 (.12)
k, N	8	1,905	4	2,004	6	1,876

Note. k = the number of independent effect sizes included in each analysis; N = sample size; M_r = mean uncorrected correlation; M_ρ = mean corrected correlation (corrected for unreliability in the predictor and criterion); 95% CI = 95% confidence interval for M_ρ; SD_ρ = standard deviation of estimated ρ*s;* $SE_{M\rho}$ = standard error of M_ρ. Values in bold indicate mean corrected correlations.

Table 9
Meta-Analysis of Relationships Between Variables in Exemplar Path Model

Variable	Conscientiousness M_r, M_ρ (95% CI)	Conscientiousness SD_ρ ($SE_{M\rho}$)	Safety climate M_r, M_ρ (95% CI)	Safety climate SD_ρ ($SE_{M\rho}$)	Safety knowledge M_r, M_ρ (95% CI)	Safety knowledge SD_ρ ($SE_{M\rho}$)	Safety motivation M_r, M_ρ (95% CI)	Safety motivation SD_ρ ($SE_{M\rho}$)	Safety performance M_r, M_ρ (95% CI)	Safety performance SD_ρ ($SE_{M\rho}$)
Conscientiousness	— (—)	— (—)								
k, N	—	—								
Safety climate	.10, **.11** (.06, .16)	.00 (.03)	— (—)	— (—)						
k, N	5	971	—	—						
Safety knowledge	.00[a] (—, —)	— (—)	.43, **.49** (.38, .59)	.08 (.05)	— (—)	— (—)				
k, N	10	1,908	3	987	—	—				
Safety motivation	.21* (—, —)	— (—)	.42, **.46** (.38, .54)	.05 (.04)	.60, **.66** (.58, .74)	.05 (.04)	— (—)	— (—)		
k, N	3	574	3	849	2	714	—	—		
Safety performance	.17, **.19** (.08, .31)	.12 (.06)	.39, **.49** (.40, .58)	.17 (.05)	.47, **.61** (.50, .72)	.15 (.06)	.50, **.57** (.36, .78)	.23 (.11)	— (—)	— (—)
k, N	6	1,421	31	15,327	9	2,893	5	1,393	—	—
Accidents and injuries	−.22, **−.26** (−.40, −.11)	.13 (.07)	−.11, **−.14** (−.17, −.11)	.07 (.02)	−.07, **−.11** (−.33, .12)	.17 (.11)	−.16, **−.20** (−.29, −.11)	.04 (.05)	−.25, **−.31** (−.54, −.31)	.28 (.12)
k, N	4	852	27	27,639	3	461	2	911	6	1,876

Note. k = the number of independent effect sizes included in each analysis; N = sample size; M_r = mean uncorrected correlation; M_ρ = mean corrected correlation (corrected for unreliability in the predictor and criterion); 95% CI = 95% confidence interval for M_ρ; SD_ρ = standard deviation of estimated ρs; $SE_{M\rho}$ = standard error of M_ρ. Values in bold indicate mean corrected correlations.
[a] Assumed values, calculated as corrected sample-weighted mean correlations derived from Barrick et al. (1993); Colquitt et al. (2000), and Maurer et al. (2008).

at this level is likely to be more potent in that people perceive the environment similarly and should thus be more influenced by it than if they had divergent perceptions. These findings are consistent with those in other domains regarding the relative influence of isomorphic (similar) constructs at the group and individual levels of analyses (e.g., see Gully, Incalcaterra, Joshi, & Beaubien, 2002).

Further, for accidents and injuries, correlations with group and organizational safety climate were significantly larger than for psychological climate. In comparing the current results with those of Clarke (2006a), we found that climate (regardless of level of analysis) was significantly correlated with safety outcomes, whereas Clarke's estimate of −.22 across all levels was not significant, a difference that is likely due to the larger sample size of the current study. Also, our estimate between psychological safety climate and safety outcomes (−.14) is lower than that observed by Clarke (−.22), but our estimates for group and organizational safety climate were much higher than Clarke's (−.38 and −.39, respectively).

Notably, our findings did not support a possible inflationary (common methods) bias for correlations with self-reported climate measures and self or supervisory safety performance ratings in relation to correlations based on self-reported climate measures and archival and medical recordings criteria. Although the number of primary studies prevented conclusive findings, our results revealed that common methods bias may not be a major concern in the safety domain. If bias does exist, the pattern of our findings would suggest that self-reports for certain types of safety criteria (e.g., safety performance or accidents/injury reports) may yield slightly downward biased underestimates of relationships involving climate as a predictor. With regard to self-reports of accidents and injuries, the slightly lower relationships may reflect artifactual or method-induced restriction in range of scores due to underreporting. However, we cautiously allude to this possibility given that the latter relationships, as evidenced by the overlapping confidence intervals, were not significantly different from each other. In general, the manner in which many variables are measured in the domain of workplace safety may preclude concerns that the measurement method greatly distorts relationships between constructs. This point is reinforced by the work of Burke, Sarpy, et al. (2002) who found minimal differences among self-, coworker, and supervisory ratings of safety performance behaviors and by the fact that the present safety performance reliabilities are uniformly higher than average criterion reliabilities reported in the applied psychology literature for coworker or supervisory ratings.

Practice Implications, Future Research Directions, and Potential Limitations

The results of this meta-analysis suggest that both the person and the situation are important factors related to workplace safety. Workers can be selected, trained, and supported through positive safety climate to maximize safety motivation and safety knowledge, which in turn leads to safe behaviors and fewer accidents and injuries. Also, our findings regarding particular individual differences suggest where to focus personnel assessments (e.g., on conscientiousness in personnel selection contexts). In addition, our findings with regard to specific climate dimensions suggest key intervention points related to enhancing workplace safety. For

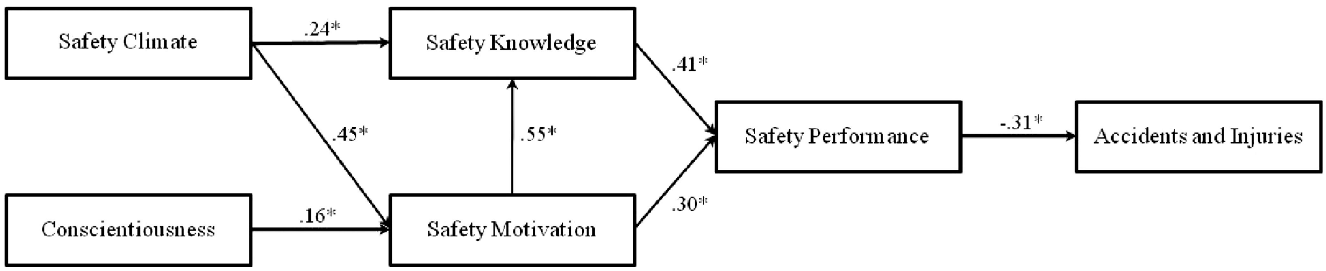

Figure 2. Maximum-likelihood parameter estimates for the hypothesized model. Statistics are standardized path coefficients. $^{*}p < .001$.

instance, interventions focused on improving management commitment to safety may meaningfully enhance safety performance and reduce accidents.

A possible future research avenue might be to examine how person and situation factors interact to influence safety. One way to approach the issue of person–situation interactions is with Schneider's (1987) attraction–selection–attrition model, which suggests that individuals are differentially attracted to, selected to, and retained within different work environments on the basis of their values, personality, and other individual differences. For example, thrill-seeking people may be more likely to seek out high-risk jobs. To the extent that risk-seeking individuals congregate in riskier environments, the organizational climate may become socially constructed to lead to riskier decisions and actions.

Furthermore, although researchers have made progress in defining and capturing safety performance behaviors (Burke, Sarpy, et al., 2002; Marchand, Simard, Carpentier-Roy, & Ouellet, 1998), they have not similarly progressed on outcome criteria. Most studies examining workplace accidents have operationalized accidents in terms of the number of *recordable accidents* as defined by OSHA, meaning those that require more than simple first aid treatment (e.g., Hofmann & Stetzer, 1996), or as lost work days resulting from an injury (e.g., Zohar, 2000). Clearly, when an injury has occurred, an accident has also taken place. However, the converse is not true; for example, a worker could fail to stabilize a ladder and suffer a fall (accident) but be fortunate enough to go uninjured. Thus, by recognizing that injuries are less common than accidents, future research could investigate how situational factors might moderate individual difference (predictor) relationships with accidents and injury criteria. For example, workers low (rather than high) in conscientiousness might be more likely to accidentally spill a noxious chemical (i.e., accident) but may be no more likely to be injured by the spill if the organization requires the use of protective clothing. Along this line, we encourage future research that examines *microaccidents,* or accidents requiring only basic first aid treatment (Zohar, 2000, 2002b). We refer the reader to Wallace and Chen (2006) and Zohar (2000, 2002b), who have highlighted methodological advantages of studying microaccidents relative to accidents.

Table 10
Direct, Indirect, and Total Effects of Person and Situation-Related Factors for Safety Performance and Safety Outcomes

Model	Direct effects	Indirect effects	Total effects
Safety performance			
Safety climate	—	.33	.33
Conscientiousness	—	.09	.09
Safety motivation	.30	.23	.52
Safety knowledge	.41	—	.41
Accidents and injuries			
Safety climate	—	−.10	−.10
Conscientiousness	—	−.03	−.03
Safety motivation	—	−.16	−.16
Safety knowledge	—	−.13	−.13
Safety performance	−.31	—	−.31

Note. All computations were conducted by inputting the harmonic mean for the sample size ($N_h = 1{,}092$).

As with any meta-analysis, the current findings are limited by the primary studies used. In general, the early literature was often difficult to integrate, in large part because many early studies failed to provide statistical information (e.g., effect sizes, sample sizes) required for a meta-analysis. Our inability to analyze such studies represents a research opportunity in that meta-analytic distributions with small numbers of effects are ones where more primary research is clearly needed. Obtaining more stable parameter estimates for some meta-analytic distributions will greatly contribute to researchers' ability to overcome issues with the use of mean corrected effects in path analyses. Additionally, the fact that few of the primary studies (12 out of 90) were longitudinal field studies limits our ability to make causal statements. For example, although reverse causality can be ruled out for distal traits' relationships with outcomes, the possibility remains that more proximal states, like safety motivation, have a reciprocal or reverse-causal relationship with safety performance. Furthermore, the safety literature on the whole could do better to develop stronger theoretical rationales and more rigorous research designs to control potentially spurious or third variable effects that could explain some of the relationships presented herein. Hence, we suggest future research is needed to further the understanding of occupational safety, particularly with an emphasis on theoretically driven longitudinal research designs.

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