Journal of Applied Psychology

0021-9010/10/$12.00 DOI: 10.1037/a0021484

Safety at Work: A Meta-Analytic Investigation of the Link Between Job Demands, Job Resources, Burnout, Engagement, and Safety Outcomes

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In this article, we develop and meta-analytically test the relationship between job demands and resources and burnout, engagement, and safety outcomes in the workplace. In a meta-analysis of 203 independent samples ($N = 186{,}440$), we found support for a health impairment process and for a motivational process as mechanisms through which job demands and resources relate to safety outcomes. In particular, we found that job demands such as risks and hazards and complexity impair employees' health and positively relate to burnout. Likewise, we found support for job resources such as knowledge, autonomy, and a supportive environment motivating employees and positively relating to engagement. Job demands were found to hinder an employee with a negative relationship to engagement, whereas job resources were found to negatively relate to burnout. Finally, we found that burnout was negatively related to working safely but that engagement motivated employees and was positively related to working safely. Across industries, risks and hazards was the most consistent job demand and a supportive environment was the most consistent job resource in terms of explaining variance in burnout, engagement, and safety outcomes. The type of job demand that explained the most variance differed by industry, whereas a supportive environment remained consistent in explaining the most variance in all industries.

Keywords: workplace safety, safety climate, meta-analysis, job demands, job resources

Each day individuals are exposed to a variety of workplace demands. Job demands, whether they are administrative hassles, emotional conflict, or role overload, require sustained physical and psychological effort, which can have significant physiological and psychological costs (Crawford, LePine, & Rich, 2010; Demerouti, Bakker, Nachreiner, & Schaufeli, 2001; Schaufeli, Bakker, & van Rhenen, 2009). The presence of job demands has been linked to increased employee burnout and absenteeism and decreased performance (e.g., Bakker & Demerouti, 2007). In high-risk environments, other job demands—including exposure to hazardous materials, cognitively challenging work, or physically demanding work—are also present, and these job demands may lead to an entirely different set of outcomes for employees, such as workplace accidents, injuries, and fatalities.

The cost of these safety-related outcomes is substantial, as it is estimated that workplace fatalities, injuries, and illnesses result in economic losses amounting to 4 to 5% of gross domestic product (World Health Organization, 2008). In 2007, this amounted to economic losses in the United States of over $550 billion (Bureau of Economic Analysis, 2008). In 2000, there were approximately two million work-related deaths (World Health Organization, 2008). Beyond the impact to individual workers themselves, occupational safety also poses a risk to others, as it is estimated that as many as 98,000 Americans die in hospitals due to errors made by medical workers (Institute of Medicine, 1999).

Given these high human and financial costs, it is important to understand how various workplace demands influence workplace safety. Fortunately, the workplace environment also provides various resources to working individuals, including job autonomy, a positive workplace climate, and coworker support (Crawford et al., 2010). These resources reduce job demands and their associated physiological and psychological costs and stimulate personal growth, learning, and development (Demerouti et al., 2001; Schaufeli et al., 2009). They have been shown to increase employee engagement, performance, and commitment (Bakker & Demerouti, 2007; Rich, LePine, & Crawford, 2010). In terms of safety outcomes, resources that may curb job demands and motivate employees include autonomy, knowledge of safety, and a supportive environment.

Although there has been considerable research on job demands and resources, we know relatively little about the implications of these demands and resources for contexts in which there are significant health and safety risks. As such, there are at least four key issues deserving additional research attention. First, we need a better understanding of which job demands and resources influence workplace safety. Although job demands and resources have been linked to organizational outcomes such as job performance,

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organizational commitment, and absenteeism (e.g., Bakker & Demerouti, 2007; Rich et al., 2010), it is equally important for organizations to understand how job demands and resources relate to safety outcomes such as accidents and injuries, adverse events, and unsafe behavior.

Second, greater understanding of the mechanisms through which job demands and resources relate to safety outcomes is needed. The job demand–resources (JD-R) model (Bakker & Demerouti, 2007; Demerouti et al., 2001) offers a potentially useful conceptual model for understanding the mechanisms through which job demands and resources relate to safety outcomes. This includes a health impairment process in which job demands exhaust an employee's mental and physical resources and thus lead to employee burnout. Alternatively, job resources create a motivational process in which the resources motivate employees toward higher engagement (Bakker & Demerouti, 2007; Demerouti et al., 2001). Because most models of workplace safety focus on motivational processes (Christian, Bradley, Wallace, & Burke, 2009; Neal & Griffin, 2004), they are incomplete in that they do not recognize the role the health impairment process might play in workplace safety.

Third, it is important to uncover which job demands and resources contribute the most to burnout, engagement, and safety outcomes. There are many job demands and resources present in the working environment, and it is important to understand which job demands deplete mental and physical resources the most and which job resources are the most motivating. This information is useful because it allows managers and organizations to adjust jobs, training, and the environment based on the factors that contribute the most to workplace safety.

Fourth, the extent to which the JD-R model generalizes across industry is unclear. Although workplace safety is a priority in many industries, workers and managers do, however, face different types of job demands and resources as well as different safety priorities, ranging from the reduction of errors in the health-care industry to the reduction of driving accidents in the transportation industry. In the current study, we explore whether job demands and job resources have the same impact across industry contexts.

Our goal was to examine the above-mentioned issues by developing and meta-analytically testing a theoretical framework of workplace safety based on the JD-R model (Bakker & Demerouti, 2007; Demerouti et al., 2001). We utilize the JD-R model to organize the various working conditions relevant for workplace safety and to explain the mechanisms through which job demands and resources relate to safety outcomes. Our theoretical model is illustrated in Figure 1, where we specify the various job demands and resources relevant for workplace safety and how they relate to burnout, engagement, and safety outcomes.

Although there have been recent meta-analyses of workplace safety (Christian et al., 2009; Clarke, 2006a; Clarke & Robertson, 2005), the current meta-analysis is the first to utilize the JD-R model. This has enabled us to connect various job demands and resources to their potential impact on safety outcomes. More important, we were able to investigate both the health impairment process and the motivational process through which job demands and resources relate to workplace safety, which is a more complete conceptualization than presented in past research. In addition, the current meta-analysis is the most comprehensive quantitative summary of the safety literature to date. Compared to other recent safety meta-analyses, this study includes over twice as many independent samples (for a total of 203 independent samples), incorporating both published and unpublished studies and a broader set of industries than previously investigated.

Theory and Hypotheses

Job Demands–Job Resources

The JD-R model (Bakker & Demerouti, 2007; Demerouti et al., 2001) proposes that job demands and resources are two sets of working conditions that can be found in every organizational context (Schaufeli et al., 2009). In the JD-R model, job demands include the physical, psychological, social, or organizational aspects of the job that require sustained physical, cognitive, or emotional effort or skills and are therefore associated with physiological and/or psychological costs. Examples of job demands include high work pressure, an unfavorable physical environment, and emotionally demanding interactions (Bakker & Demerouti, 2007; Demerouti et al., 2001). Job demands may be inherently negative, or they may turn into job stressors when meeting the demands requires high effort on the part of the employee from

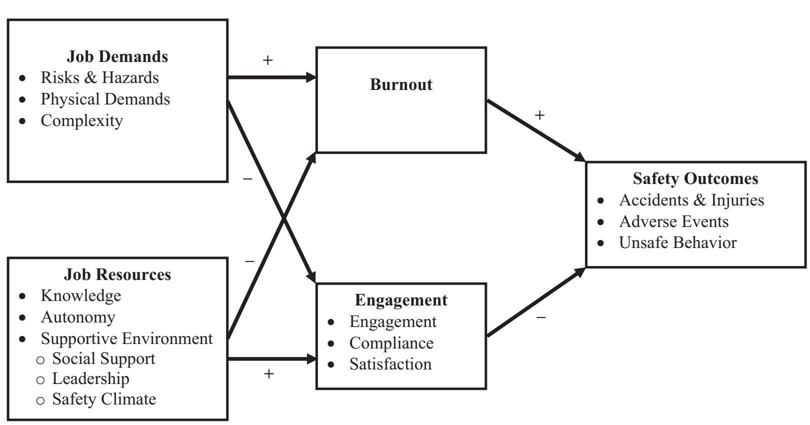

Figure 1. Job demands–job resources model of workplace safety.

which the employee may not adequately recover (Bakker & Demerouti, 2007; Meijman & Mulder, 1998).

The second set of working conditions is job resources, which not only help employees deal with job demands but also have the potential to motivate employees. Job resources include physical, psychological, social, or organizational aspects of the job that help employees achieve work goals, reduce job demands and the associated physiological and psychological costs, and/or stimulate personal growth and development. Examples of job resources include autonomy, coworker support, and feedback. Thus, job resources can be derived from the organization (e.g., pay, job security), interpersonal and social relations (e.g., supervisor and coworker support), organization of work (e.g., participation in decision making), and the task (e.g., autonomy, feedback; Bakker & Demerouti, 2007; Demerouti et al., 2001).

In the context of workplace safety, working conditions can also be categorized as job demands and resources (see Figure 1). Thus, working conditions categorized as job demands in the context of safety include *risks and hazards* present in the workplace, *physical demands* associated with the work, as well as the *complexity* of the work. Previous research utilizing the JD-R model has identified aspects of the physical environment, such as noise and materials, as job demands (Demerouti et al., 2001). In the context of safety, risks and hazards constitute the environmental and workplace conditions or exposures, which include possible loss of life, injury, or chance of danger. Examples include noise, heat, dust, chemicals, and hazardous tools and equipment (DeJoy, Schaffer, Wilson, Vandenberg, & Butts, 2004). Although some risks and hazards may be avoided by employees, the mere presence of risks and hazards is likely to increase employees' perceptions of danger in the workplace and to be associated with psychological costs. Furthermore, employees may expend increased effort not only to handle risks and hazards but to circumvent risks and hazards.

The two remaining job demands include physical demands and complexity of the work. According to the JD-R model, physical demands and complexity of the work constitute job demands because both require sustained physical or cognitive effort and skill (Bakker & Demerouti, 2007; Demerouti et al., 2001). In the context of safety, the physical demands of the work reflect physical aspects of the job or the surrounding context that require sustained physical effort. Examples include the condition in which the work is performed, scheduling and workload, and physical demands of the work. Finally, the overall complexity of the work is another job demand that includes aspects of the job that require mental effort, such as cognitive demands, task complexity, and ambiguity in the work.

Working conditions categorized as job resources include *knowledge* of safety, *autonomy,* and a *supportive environment*. Knowledge may be categorized as a job resource because it provides employees with the resources to achieve their work goals as well as to reduce job demands (Bakker & Demerouti, 2007; Demerouti et al., 2001). Thus, in the context of safety, knowledge of safety provides employees with the resource of knowing what to do regarding safety (i.e., employee understanding of safety policies and procedures) and how to perform safely (i.e., training on safety; Campbell, 1990). Knowledge includes such things as knowing how to use personal protective equipment, engaging in work practices to reduce risk, and understanding general health and safety (Burke, Sarpy, Tesluk, & Smith-Crowe, 2002).

Autonomy is a working condition that has long been acknowledged as a valuable resource for employees (e.g., Karasek, 1979). Autonomy represents the freedom individuals have in carrying out their work, including freedom regarding scheduling work, decision making, and work methods (Hackman & Oldham, 1976; Morgeson & Humphrey, 2006). Research utilizing the JD-R model has previously classified autonomy as a job resource (Demerouti et al., 2001; Schaufeli et al., 2009). In the context of safety, the freedom to carry out their work allows employees to achieve their work goals in terms of both productivity and safety outcomes as well as to reduce job demands. It thus constitutes a job resource.

The final job resource includes a *supportive environment,* which can be further delineated in terms of the source of the support. Previous research on the JD-R model has consistently classified supervisor support (i.e., leadership), social support, and workplace climate as job resources (Crawford et al., 2010; Demerouti et al., 2001; Schaufeli et al., 2009). Thus, in the context of safety, employees may receive *leadership* support by way of leaders communicating the value of safety to their employees, helping employees develop new ways to achieve safety, and having a concern about employee safety (Zacharatos, Barling & Iverson, 2005; Zohar, 2002a, 2002b). Employees may also receive *social support,* which includes the degree of advice and assistance from others, support regarding safety, and an emphasis on teamwork (Morgeson & Humphrey, 2006). The final source of support comes from the organization in the form of *safety climate*. In general, climate can be defined as the perceptions of the events, practices, and procedures as well as the kind of behaviors that are rewarded, supported, and expected in a particular organizational setting (Schneider, 1990). Thus, safety climate encompasses perceptions of safety-related events, practices, and procedures as well as the types of safety-oriented behaviors that are rewarded, supported, and expected (Zohar, 1980). The three sources of a supportive environment constitute job resources because they may help employees achieve work goals through the advice and assistance received from others, reduce job demands by helping them develop new ways to achieve safety, and motivate the development of safety behaviors rewarded by the environment.

Job Demands–Job Resources Relationship With Burnout and Engagement

Beyond the premise that job demands and resources represent two sets of working conditions found in every organizational context, the JD-R model proposes that job demands and resources play a role in the development of burnout and engagement (Bakker & Demerouti, 2007; Crawford et al., 2010; Demerouti et al., 2001). Burnout is traditionally characterized as a syndrome of exhaustion, cynicism, and lack of efficacy experienced by employees (Maslach & Leiter, 1997, 2008). In contrast to burnout, engagement was originally defined as the harnessing of organization members' selves to the work roles by which the organization members employ and express themselves physically, cognitively, and emotionally (Kahn, 1990, p. 694). More recently, Schaufeli, Salanova, González-Romá, and Bakker (2002) have defined engagement as a positive, fulfilling, work-related state of mind characterized by vigor, dedication, and absorption (p. 74).

In the context of workplace safety, burnout is reflected in negative employee well-being, which includes worker anxiety, health, and depression, and work-related stress. Employee engagement represents the extent of involvement, participation, and communication in safety-related activities (Hofmann & Morgeson, 1999; Neal & Griffin, 2006; Parker, Axtell, & Turner, 2001) and compliance, or the extent to which employees conform or submit to safety expectations, rules, and procedures. The positive state of employee satisfaction and commitment to the organization can also be characterized as engagement.

According to the JD-R model, job demands evoke a health impairment process that exhausts employees' mental and physical resources and therefore leads to burnout. Thus, job demands are predicted to have a direct positive relationship with burnout (Bakker & Demerouti, 2007; Crawford et al., 2010; Demerouti et al., 2001). With high job demands, it is likely that workers will have limited capacity to handle the physical and cognitive demands of the work and safety performance. Thus, exposure to risks and hazards, high physical demands, and complexity will deplete employees' mental and physical resources and ultimately result in burnout. Empirical research has found that hazards and high workload are positively related to depression and somatic symptoms (Frone, 1998). We expect that job demands such as risks and hazards, physical demands, and complexity will have a positive relationship with burnout.

Hypothesis 1: Job demands are positively related to burnout.

Empirical evidence on the relationship of job demands to engagement has been mixed (Bakker, van Emmerik, & Euwema, 2006; Schaufeli & Bakker, 2004; Schaufeli, Taris, & van Rhenen, 2008), although recent meta-analytic work suggests the relationship between job demands and engagement depends on whether the demand is a challenge or a hindrance demand (Crawford et al., 2010). Challenge demands promote mastery, personal growth, or future gains, and employees view these demands as opportunities to learn, achieve, and demonstrate competence. Hindrance demands impede personal growth, learning, and goal attainment and are generally seen by employees as constraints, barriers, or roadblocks that hinder progress toward goals and effective performance (Cavanaugh, Boswell, Roehling, & Boudreau, 2000). Examples of challenge demands include time pressure and high levels of responsibility, whereas hindrance demands include role conflict, role ambiguity, and role overload. Challenge demands have been found to be positively related to engagement, whereas hindrance demands have been found to be negatively related to engagement (Crawford et al., 2010).

Risks and hazards, physical demands, and complexity are hindrance demands because they have the potential to hinder safety. Risks and hazards impede progress toward working safely, whereas physical demands and complexity constrain an employee's progress toward working safely. Due to these barriers and constraints, workers are less likely to engage in safety activities, comply with safety procedures, or be satisfied. Empirical research has found risks and hazards are negatively related to employee involvement in safety activities, compliance, and job satisfaction (DeJoy et al., 2004; Frone, 1998; Goldenhar, Williams, & Swanson, 2003). Research has also found negative relationships between role overload and safety compliance and working safely (Hofmann & Stetzer, 1996; Wallace & Chen, 2005). Finally, work design research has found that increased physical demands are negatively related to job satisfaction (Humphrey, Nahrgang, & Morgeson, 2007). Thus, we expect risks and hazards, physical demands, and complexity will be negatively related to engagement, compliance, and satisfaction.

Hypothesis 2: Job demands are negatively related to engagement.

The JD-R model also proposes that job resources evoke a motivational process that leads to higher work engagement. Job resources may be intrinsically motivating by fostering employee growth and learning, or they may be extrinsically motivating because they allow employees to achieve their goals. Thus, job resources are predicted to have a direct positive relationship with engagement (Bakker & Demerouti, 2007; Crawford et al., 2010; Demerouti et al., 2001). We expect that knowledge, autonomy, and a supportive environment will be positively related to employee engagement in safety activities, compliance, and satisfaction. Knowledge of safety fosters employee growth and learning in using personal protective equipment, safety work practices, and general health and safety (Burke et al., 2002). Research has found a positive relationship between training related to personal protective equipment and compliance in wearing personal protective equipment (Smith-Crowe, Burke, & Landis, 2003). Likewise, autonomy fulfills a basic need for freedom and provides employees with discretion in their work, thus enabling them to achieve their goals. Autonomy has been found to be positively related to safety communication and commitment (Parker et al., 2001) and has also been found to be positively related to job satisfaction (Humphrey et al., 2007).

Finally, a supportive environment will also motivate employees toward higher engagement. A supportive environment sends a signal that workers are valued and that the organization is committed to them (Eisenberger, Fasolo, & Davis-LaMastro, 1990; Eisenberger, Huntington, Hutchison, & Sowa, 1986; Hofmann & Morgeson, 1999). Therefore, workers will be motivated to participate in safety prevention activities such as compliance, engage in higher levels of safety communication and involvement in safety activities, and be more satisfied with their work. Research has found that a supportive environment is positively related to safety communication and worker involvement (Hofmann & Morgeson, 1999; Mohamed, 2002), safety compliance (Goldenhar et al., 2003), and job satisfaction (Humphrey et al., 2007). The safety climate in an organization also communicates the types of safety-oriented behaviors that are rewarded, supported, and expected and thus motivates employees to achieve safety goals. Research has found a positive relationship between safety climate and participation in safety activities, compliance with safety, and work satisfaction (Hofmann & Stetzer, 1998; Morrow & Crum, 1998; Neal & Griffin, 2006). Thus, we expect knowledge, autonomy, and a supportive environment will be positively related to engagement, compliance, and satisfaction.

Hypothesis 3: Job resources are positively related to engagement.

Empirical evidence also suggests that job resources have a direct negative relationship with burnout because larger pools of resources enable employees to meet demands and protect themselves from strain. In contrast, with limited resources employees are unable to meet demands and thus accrue strain over time, resulting in burnout (Bakker, Demerouti, & Euwema, 2005; Bakker, Demerouti, & Schaufeli, 2003; Hobfoll & Freedy, 1993; Lee & Ashforth, 1996; Schaufeli & Bakker, 2004). We also expect that knowledge, autonomy, and a supportive environment will be negatively related to burnout. Knowledge of safety procedures or training in safety provides a resource for employees to draw from in order to mitigate demands and thus reduce strain. Indeed, research has found safety-related training to be negatively related to stress (Fogarty, 2005). Autonomy also provides employees with another resource in order to meet job demands. Jobs high in autonomy provide employees with the freedom to decide how to meet job demands and thus reduce the potential for strain (Karasek, 1979). Research with nurses has found that autonomy is negatively related to stress (Hemingway & Smith, 1999).

Finally, a supportive environment enables employees to cope with the negative influences of job demands (Demerouti et al., 2001). Support at work is one of the most important determinants of well-being (Myers, 1999) and helps to reduce stress by buffering workers against negative job events (Karasek, 1979; Karasek, Triantis, & Chaudhry, 1982). Likewise, support for safety may help to buffer employees from the anxiety, stress, and burnout that come from dealing with safety issues or risks and hazards (Halbesleben, 2006). Thus, we expect that a supportive environment will also be negatively related to employee burnout. Meta-analytic evidence has shown that social support is negatively related to anxiety, stress, and burnout and exhaustion (Halbesleben, 2006). Likewise, strong leadership in a hospital was found to be negatively related to the burnout and exhaustion of nurses (Laschinger & Leiter, 2006). Among construction workers, safety climate was found to be negatively related to psychological and physical symptoms such as anger, insomnia, and pain (Goldenhar et al., 2003). Thus, we expect that knowledge, autonomy, and a supportive environment will be negatively related to burnout.

Hypothesis 4: Job resources are negatively related to burnout.

Relationship of Burnout and Engagement to Safety Outcomes

Recent work has expanded the JD-R model to assess the extent to which burnout and engagement predict outcomes such as performance, citizenship behaviors, and absenteeism (e.g., Rich et al., 2010; Schaufeli et al., 2009). In general, the JD-R model proposes that exhaustion, cynicism, and lack of efficacy on the part of employees will be detrimental to performance and lead to higher absenteeism (Bakker & Demerouti, 2007). In contrast, engaged employees will focus their physical, cognitive, and emotional efforts toward goal attainment, thus leading to higher performance and citizenship behaviors (Rich et al., 2010). In the context of workplace safety, our primary interest is the relationship of burnout and engagement to outcomes such as accidents and injuries, adverse events, and unsafe behavior (Neal & Griffin, 2004).

We expect that burnout will be positively related to accidents and injuries, adverse events, and unsafe behavior. With burnout, an employee's mental and physical energy is depleted. Thus, employees are more likely to commit mistakes and injure themselves. Likewise, employees are unlikely to have the mental or physical energy to perform safe behaviors. Indeed, research on construction workers has found that psychological distress is positively related to accidents and injuries (Siu, Phillips, & Leung, 2004). Burnout among nurses has also been found to be positively related to adverse events (Laschinger & Leiter, 2006). Thus, we expect burnout will be positively related to accidents and injuries, adverse events, and unsafe behavior.

In contrast, we expect that engagement will be negatively related to accidents and injuries, adverse events, and unsafe behavior. Through increased engagement activities workers have more control over the situation and thus are able to limit the number of accidents, injuries, and adverse events. Research has found a negative relationship between safety communication and accidents (Hofmann & Morgeson, 1999). Likewise, we also expect that engagement in complying with safety procedures and activities will be negatively related to accidents and injuries and adverse events. Research has found that compliance was negatively related to near misses (Goldenhar et al., 2003). We expect that engagement, compliance, and satisfaction will be negatively related to accidents and injuries, adverse events, and unsafe behavior.

Hypothesis 5: Burnout is positively related to safety outcomes.

Hypothesis 6: Engagement is negatively related to safety outcomes.

Mediating Role of Burnout and Engagement

We proposed, following the JD-R model, that job demands and resources would be related to burnout and engagement. In summary, job demands will exhaust an employee's mental and physical resources, thereby increasing burnout and hindering engagement in safety activities. In contrast, job resources motivate employees toward higher engagement as well as replenish an employee's resources and offset the degree of burnout. We then hypothesized that employees who experience burnout are more likely to commit mistakes and injure themselves, whereas engaged employees are more likely to focus their efforts toward working safely and thus be less likely to injure themselves or others. Thus, a remaining question concerns how job demands and resources are translated into safety outcomes such as accidents, injuries, and adverse events.

Previous research supports the direct relationship between job demands and resources and safety outcomes in that higher workload and risks have been associated with more work injuries and negative safety-related events (Evans, Michael, Wiedenbeck, & Ray, 2005; Frone, 1998). Knowledge of safety and a supportive environment have also been found to negatively relate to safety errors and accidents and injuries (Hofmann & Stetzer, 1996; Katz-Navon, Naveh, & Stern, 2007; Zohar & Luria, 2004). Thus, the hypotheses advanced earlier suggest that burnout and engagement mediate the relationship between job demands and resources and safety outcomes in two ways. First, to avoid accidents, injuries, and adverse events, employees must be able to utilize their full mental and physical capacities. In addition, in order to perform their jobs productively as well as safely, employees must extend a large amount of effort. Unfortunately, in the effort to meet increased job demands, such as risks and hazards, complexity, and physical demands, an employee's mental and physical capacities are depleted, which results in burnout for the employee. Having to extend effort to meet the increased job demands also decreases effort toward engaging in safety activities. Thus, employees become mentally and physically exhausted as well as unwilling to engage in activities that will keep them safe from harm. In this state, employees are more likely to injure themselves, commit mistakes, or experience other adverse safety outcomes.

Second, employees need to be motivated to perform safely as well as to have ways to replenish their mental and physical capacities. Increased job resources, such as knowledge, autonomy, and a supportive environment foster employee growth and learning and allow employees to achieve their goals. In addition, these job resources help employees to offset the negative influences of demands in the workplace. Thus, employees are motivated to engage in safety activities and are less likely to suffer from burnout because job resources will replenish their mental and physical capacities. In this motivated and healthy state, employees are less likely to experience adverse safety outcomes. Research has indeed found that psychological strain mediates the relationship between safety climate and safety outcomes such as errors and accident rates (Fogarty, 2005; Siu et al., 2004). Thus, we propose that burnout and engagement will mediate the relationship between job demands and resources and safety outcomes.

> *Hypothesis 7:* Burnout mediates the relationship between (a) job demands and (b) job resources and safety outcomes.

> *Hypothesis 8:* Engagement mediates the relationship between (a) job demands and (b) job resources and safety outcomes.

Generalization Within and Across Industries

The JD-R model posits that job demands and resources can be found in every organizational context (Schaufeli et al., 2009). Yet industries differ with respect to the types of job demands inherent in the work. For example, in the construction industry, workers are exposed to hazards such as asbestos, chemicals, and lead (Goldenhar et al., 2003), whereas in the health-care industry, nurses face inherent role conflict and role ambiguity based on opposing demands made by medical and administrative staff (Hemingway & Smith, 1999). In addition, industries differ with the types of risks in the workplace and whether or not those risks pose a risk to the self versus others. For example, unsafe performance in the manufacturing industry primarily poses a risk to the self, or individual employee, whereas unsafe performance in the health-care industry can pose a risk to others, or patients. Likewise, industries differ in the types of safety outcomes, ranging from falls in the construction industry, driving accidents in the transportation industry, and medication errors in the health-care industry. Thus, the current study explores the extent to which the relationship of job demands and resources to burnout, compliance, and safety outcomes generalize across industry.

Method

Literature Search and Coding Procedures

A literature search was conducted to identify published articles, conference papers, doctoral dissertations, and unpublished manuscripts related to safety climate. The articles were identified through computer-based searches of the PsycINFO (1887–2009), ISI Web of Science (1970–2009), and Medline (1950–2009) databases in order to identify safety research that has been published in the psychology, management, and medical literatures. Searches included the terms *workplace safety, safe behavior, safe behavior, safety performance, safety climate,* and *safety culture*. Results of this search identified 2,134 articles. The electronic search was supplemented with a manual search of reference lists of key empirical and theoretical articles on safety, conference programs, and personal communication with safety researchers. The abstracts obtained as result of these searches were reviewed, and theoretical work, literature reviews, and studies outside of the context of work were eliminated for inclusion in the meta-analysis. We then examined the remaining empirical articles (960 studies) for appropriate content. If the study had sufficient information (e.g., effect sizes, description of variables, and description of sample) to code the study, it was included in the meta-analysis. Our final set includes 179 studies, with 20 articles reporting more than one independent sample for a total of 203 independent samples (N = 186,440). The samples were considered independent if participants in one sample were not participants in the other sample.

All three authors participated in the coding of the studies. Each author coded approximately one third of the studies. Interrater agreement was assessed on a random sample of 20 studies (~10% of the 179 studies). Initial agreement was 79%, which is similar to that for other published meta-analyses (Heidemeier & Moser, 2009). After independently coding each manuscript, the authors met together weekly to discuss the manuscripts coded that week. During the meetings, the authors clarified any ambiguous coding situations (e.g., whether a variable represented construct A or construct B), discussed whether an article's dataset was unique, and worked to achieve consensus on any issues among the authors.

Coded Variables

Job demands. *Risks and hazards* includes perceived risk, level of risk, number of hazards, and perceptions of safety. Perceptions of safety was reverse coded so that the construct represents high levels of risks and hazards. *Physical demands* includes physical demands, workload, and work pressure or high work pace. *Complexity* includes cognitive demands, task complexity, and ambiguity.

Job resources. *Knowledge* includes employee understanding of safety, policies, rules and procedures, as well as safety training. *Social support* includes involvement and support from coworkers, teamwork, and coworker support for safety. *Leadership* includes styles of leadership (i.e., transformational), relationships between leaders and workers (i.e., leader–member exchange), trust, and supervisor support for safety. Variables were coded so that the construct represents positive leadership. *Safety climate* includes the overall perceptions of the safety climate, the perceptions of management's involvement in safety, and proactive management of safety.

Burnout. *Burnout* includes worker anxiety, health, and depression, and work- related stress.

Engagement. *Engagement* includes worker participation in safety as well as safety communication and information sharing with workers. *Compliance* includes compliance with safety and preventative measures such as personal protection equipment and housekeeping. *Satisfaction* includes job and organizational satisfaction and organizational commitment.

Safety outcomes. *Accidents and injuries* includes accident and injury rates and injury severity. *Adverse events* includes near misses, safety events, and errors. *Unsafe behavior* includes unsafe behaviors, absence of safety citizenship behaviors, and negative health and safety. Safety outcomes were coded such that a higher score on the variable represents increased frequency of occurrence.

Industry. Based on the sample description, the industry sector the sample was drawn from was coded (with Standard Industrial Classification codes). The four primary industries represented were construction, health care, manufacturing/processing, and transportation.

Meta-Analytic Procedures and Analyses

We utilized the Hunter–Schmidt psychometric meta-analysis method (Hunter & Schmidt, 2004) to conduct the meta-analytic review. The observed correlations were corrected for sampling error and for measurement unreliability. We corrected the correlations from individual samples for measurement error in both the predictor and the criterion scores using Cronbach's alpha coefficient. The majority of studies provided Cronbach's alpha coefficient for the measured variables. For the studies missing this reliability coefficient, we used the average value from the other studies (Hunter & Schmidt, 2004). We did not correct for measurement error when objective measures were used in the study (i.e., accident rates from archival records). For studies that provided multiple estimates of the same relationship, we combined these estimates into a single correlation using the composites formula when possible or averaging the estimates. This prevented a study being "double-counted" in the meta-analysis. In contrast, studies that included multiple independent samples were separately coded.

We present several pieces of information about the population correlation estimates. First, we include both the uncorrected (r) and corrected (r_c) estimates. Second, we include the 90% confidence interval (CI) and 80% credibility interval (CV) for each corrected population correlation. Confidence intervals provide an estimate of the variability around the estimated mean correlation; a 90% CI (around a positive value) excluding zero indicates that one can be 95% confident that the average true score correlation is larger than zero (for positive correlations, less than 5% are zero or less and a maximum of 5% are larger than the upper bound of the interval). Credibility intervals provide an estimate of the variability of individual correlations across studies; a 80% CV excluding zero indicates that at least 90% of the individual correlations in the meta-analysis were greater than zero (for positive correlations, less than 10% are zero or less and a maximum of 10% lie beyond the upper bound of the interval). Thus, confidence intervals estimate variability in the meta-analytic correlation, whereas credibility intervals estimate variability in the individual (primary) correlations across the samples included in the respective analysis. Finally, we present the number of studies included in determining the correlation (k) and the total number of participants in the studies (N). In the following discussion of the correlation results, correlations were interpreted as significant at $p <$ .05 if the confidence interval did not include zero.

In our analyses of relative importance and mediation, we utilized matrices of the relevant estimated true score correlations that were derived with the procedures outlined above. For example, when analyzing the relative importance of job demands to burnout, we used a meta-analytic correlation matrix that included the true score correlations of risks and hazards, complexity, physical demands, and burnout. We also utilized the harmonic means of the cell sample sizes according to procedures outlined by Viswesvaran and Ones (1995). Research investigating the use of meta-analytic correlation matrices in several simulation studies has found that parameter estimates remain accurate and that goodness-of-fit indices such as the comparative fit index (CFI) and standardized root mean square residual (SRMR) function well (Beretvas & Furlow, 2006; Cheung & Chan, 2005; Furlow & Beretvas, 2005). Another concern in using a meta-analytic correlation matrix is that different studies contribute to different cells in the matrix (i.e., sample size varies across cells). Research has found parameter estimates and chi-square tests to be biased when data in a meta-analytic matrix are missing not at random (Furlow & Beretvas, 2005; Naragon-Gainey, 2010). Potential limitations of meta-analytic correlation matrices are noted in the current study.

Results

Job Demands–Job Resources Relationship With Burnout and Engagement

Table 1 presents the correlation results for the relationship of job demands and job resources. Table 2 presents the correlation results for the relationship of job demands and resources to burnout, engagement, and safety outcomes. Hypothesis 1 predicted that job demands would be positively related to burnout. Results showed that both risks and hazards and complexity were significantly related to burnout (r_c = .28, r_c = .24, respectively). Physical demands did not demonstrate a meaningful relationship with burnout. Two of the three job demands were significantly related to burnout, thus partially supporting Hypothesis 1. Hypothesis 2 predicted job demands would be negatively related to engagement. Risks and hazards and complexity were both significantly related to engagement (r_c = −.67, r_c = −.52, respectively), whereas physical demands was not. Risks and hazards, physical demands, and complexity were also found to be significantly related to compliance (r_c = −.75, r_c = −.24, r_c = −.41, respectively). Physical demands and complexity were found to be significantly related to satisfaction (r_c = −.44, r_c = −.36, respectively), whereas risks and hazards was not. In total, seven of the nine hypothesized relationships were significant, thus largely supporting Hypothesis 2. The above pattern of results suggests support for the JD-R model in that the majority of job demands were positively related to burnout and negatively related to engagement.

Hypothesis 3 predicted that job resources would be positively related to engagement. There was strong support for this hypothesis in that knowledge, social support, leadership, and safety climate were all significantly related to engagement, compliance, and satisfaction (ranges from r_c = .30 for autonomy–engagement to r_c = .87 for social support–satisfaction). Hypothesis 4 predicted that job resources would be negatively related to burnout. Again, the results provided strong support for this hypothesis in that knowledge, autonomy, social support, leadership, and safety climate all demonstrated significant relationships with burnout (r_c = −.24, r_c = −.39, r_c = −.26, r_c = −.36, r_c = −.37, respectively). The above pattern of results again suggests support for the JD-R model in that all of the job resources were positively related to engagement and negatively related to burnout.

Table 1
Relationship of Job Demands and Job Resources

	Job demands			Job resources			
Variable	Risks and hazards	Physical demands	Complexity	Knowledge	Autonomy	Social support	Leadership
Job demands							
Physical demands							
r, r_c	.22, .30						
95% CI	(0.12, 0.49)						
90% CV	(−0.11, 0.71)						
k; N	12; 8,554						
Complexity							
r, r_c	.15, .19	.15, .20					
95% CI	(0.13, 0.26)	(0.10, 0.29)					
90% CV	(0.19, 0.19)	(0.00, 0.39)					
k; N	2; 681	10; 20,396					
Job resources							
Knowledge							
r, r_c	−.29, −.37	−.01, −.01	−.11, −.14				
95% CI	(−0.44, −0.30)	(−0.13, 0.11)	(−0.30, 0.02)				
90% CV	(−0.55, −0.18)	(−0.39, 0.37)	(−0.40, 0.12)				
k; N	17; 25,047	23; 13,013	7; 2,347				
Autonomy							
r, r_c	−.12, −.16	−.13, −.17	−.31, −.40	.31, .42			
95% CI	(−0.26, −0.05)	(−0.34, −0.00)	(−0.58, −0.23)	(0.24, 0.61)			
90% CV	(−0.21, −0.11)	(−0.45, 0.11)	(−0.67, −0.14)	(0.12, 0.73)			
k; N	2; 770	7; 2,470	6; 1,671	7; 1,186			
Social support							
r, r_c	−.53, −.71	−.52, −.68		.28, .37	.33, .40		
95% CI	(−0.80, −0.62)	(−1.00, −0.36)		(0.27, 0.48)	(0.27, 0.53)		
90% CV	(−0.92, −0.49)	(−1.00, 0.04)		(0.18, 0.57)	(0.24, 0.55)		
k; N	14; 30,123	12; 18,391		9; 9,186	4; 1,638		
Leadership							
r, r_c	−.34, −.43	−.50, −.63	−.24, −.30	.36, .46	.33, .40	.58, .74	
95% CI	(−0.52, −0.35)	(−0.85, −0.41)	(−0.45, −0.15)	(0.37, 0.56)	(0.33, 0.47)	(0.68, 0.81)	
90% CV	(−0.71, −0.16)	(−1.00, 0.03)	(−0.50, −0.10)	(0.17, 0.75)	(0.29, 0.50)	(0.56, 0.93)	
k; N	24; 15,582	22; 20,730	5; 1,935	22; 9,528	6; 7,656	20; 25,863	
Safety climate							
r, r_c	−.47, −.60	−.38, −.48	−.33, −.42	.44, .57	.40, .51	.66, .80	.57, .69
95% CI	(−0.68, −0.51)	(−0.65, −0.32)	(−0.56, −0.29)	(0.50, 0.64)	(0.37, 0.65)	(0.72, 0.89)	(0.63, 0.76)
90% CV	(−0.95, −0.24)	(−1.00, 0.22)	(−0.66, −0.18)	(0.23, 0.91)	(0.25, 0.77)	(0.50, 1.00)	(0.38, 1.00)
k; N	43; 51,823	44; 31,924	8; 3,384	55; 31,359	9; 2,430	31; 61,034	53; 29,114

Note. 95% CI = 95% confidence interval around r_c; 90% CV = 90% credibility interval around r_c.

Relationship of Burnout and Engagement to Safety Outcomes

Table 3 presents the correlation results for the relationship of burnout, engagement, and safety outcomes. Hypothesis 5 predicted that burnout would be positively related to safety outcomes. Results indicate that burnout was significantly related to accidents and injuries (r_c = .13) and adverse events (r_c = .29) but was not significantly related to unsafe behavior. Thus, there was partial support for Hypothesis 5. Hypothesis 6 predicted that engagement would be negatively related to safety outcomes. Engagement was found to be significantly related to adverse events and unsafe behavior (r_c = −.32, r_c = −.28, respectively), but was not significantly related to accidents and injuries. Compliance and satisfaction were both significantly related to all three safety outcomes (ranges from r_c = −.11 for satisfaction–accidents and injuries to r_c = −.49 for compliance–adverse events). In total, eight of the nine hypothesized relationships were significant, thus largely supporting Hypothesis 6. This set of results also suggests support for the JD-R model in that burnout was positively related to the majority of safety outcomes and engagement was negatively related to the majority of safety outcomes.

Examining Relative Importance of Job Demands–Job Resources, Burnout, and Engagement

We also sought to understand which job demands and resources contribute the most to burnout, engagement, and safety outcomes, as well as whether burnout or engagement contributes the most to safety outcomes, by examining their relative importance. Relative importance is defined as "the proportionate contribution each predictor makes to R^2, considering both its direct effect (i.e., its correlation with the criterion) and its effect when combined with the other variables in the regression equation" (Johnson & Lebreton, 2004, p. 240). Relative importance of predictors is often examined through regression coefficients or zero-order correlations with the criterion. When predictors are uncorrelated, these indices are appropriate for determining relative importance because they are equivalent and the squares of the indices

Table 2
Relationship of Job Demands–Job Resources to Burnout, Engagement, and Safety Outcomes

Variable	Burnout	Engagement			Safety outcomes		
		Engagement	Compliance	Satisfaction	Accidents and injuries	Adverse events	Unsafe behavior
Job demands							
Risks and hazards							
r, r_c	.24, .28	−.48, −.67	−.49, −.75	−.08, −.10	.11, .13	.29, .43	.09, .12
95% CI	(0.18, 0.39)	(−0.76, −0.59)	(−0.90, −0.59)	(−0.25, 0.06)	(0.06, 0.20)	(0.31, 0.55)	(0.01, 0.23)
90% CV	(0.10, 0.46)	(−0.92, −0.43)	(−.1.00, −0.37)	(−0.43, 0.23)	(−0.09, 0.35)	(0.18, 0.68)	(−0.17, 0.41)
k; *N*	8; 3,007	18; 31,996	14; 27,766	11; 6,757	21; 28,315	10; 27,807	16; 6,232
Physical demands							
r, r_c	.01, .01	−.12, −.28	−.16, −.24	−.34, −.44	.07, .09	.10, .13	.19, .28
95% CI	(−0.22, 0.24)	(−0.49, 0.08)	(−0.35, −0.12)	(−0.74, −0.15)	(0.05, 0.13)	(−0.02, 0.29)	(0.13, 0.42)
90% CV	(−0.49, 0.51)	(−0.89, 0.33)	(−0.62, 0.14)	(−1.00, 0.13)	(−0.02, 0.20)	(−0.22, 0.49)	(−0.16, 0.72)
k; *N*	11; 4,890	21; 11,284	24; 11,668	9; 29,367	18; 24,104	13; 5,680	22; 9,777
Complexity							
r, r_c	.19, .24	−.39, −.52	−.31, −.41	−.28, −.36	.08, .11	.15, .19	.30, .43
95% CI	(0.03, 0.44)	(0.71, −0.33)	(−0.66, −0.16)	(−0.46, −0.26)	(0.02, 0.21)	(0.13, 0.25)	(0.22, 0.63)
90% CV	(−0.05, 0.52)	(−0.82, −0.22)	(−0.77, −0.06)	(−0.46, −0.25)	(0.00, 0.23)	(0.19, 0.19)	(0.07, 0.78)
k; *N*	5; 1,467	6; 2,441	5; 2,071	5; 756	5; 1,190	3; 1,054	7; 3,620
Job resources							
Knowledge							
r, r_c	−.19, −.24	.35, .47	.37, .48	.28, .37	−.07, −.08	−.12, −.16	.−.20, −.25
95% CI	(−0.45, −0.03)	(0.42, 0.53)	(0.41, 0.55)	(0.22, 0.53)	(−0.14, −0.03)	(−0.26, −0.07)	(−0.39, −0.12)
90% CV	(−0.64, 0.15)	(0.26, 0.68)	(0.21, 0.75)	(0.01, 0.73)	(−0.27, 0.09)	(−0.38, 0.05)	(−0.67, 0.17)
k; *N*	8; 3,467	33; 19,750	36; 18,154	13; 4,457	28; 31,491	13; 4,347	23; 13,121
Autonomy							
r, r_c	−.30, −.39	.24, .30		.28, .37	−.07, −.09	−.23, −.35	−.14, −.18
95% CI	(−0.44, −0.35)	(0.13, 0.48)	—	(0.32, 0.42)	(−0.17, −0.01)	(−0.59, −0.11)	(−0.28, −0.07)
90% CV	(−0.39, −0.39)	(0.08, 0.53)		(0.29, 0.46)	(−0.23, 0.04)	(−0.61, −0.08)	(−0.29, −0.06)
k; *N*	5; 1,556	5; 616		8; 23,169	6; 23,767	3; 822	4; 1,017
Social support							
r, r_c	−.22, −.26	.51, .69	.50, .67	.68, .87	−.37, −.44	−.28, −.38	−.25, −.35
95% CI	(−0.36, −0.15)	(0.63, 0.75)	(0.60, 0.74)	(0.64, 1.00)	(−0.74, −0.14)	(−0.51, −0.25)	(−0.47, −0.24)
90% CV	(−0.40, −0.11)	(0.53, 0.84)	(0.56, 0.78)	(0.57, 1.00)	(−0.99, 0.11)	(−0.63, −0.14)	(−0.56, −0.14)
k; *N*	6; 2,168	17; 43,935	6; 27,518	4; 13,367	8; 3,218	8; 26,332	8; 16,480
Leadership							
r, r_c	−.32, −.36	.48, .63	.44, .59	.70, .86	−.12, −.14	−.18, −.22	−.23, −.32
95% CI	(−0.45, −0.28)	(0.55, 0.71)	(0.50, 0.68)	(0.73, 0.99)	(−0.23, −0.05)	(−0.28, −0.15)	(−0.42, −0.23)
90% CV	(−0.53, −0.20)	(0.34, 0.92)	(0.31, 0.87)	(0.61, 1.00)	(−0.45, 0.17)	(−0.39, −0.05)	(−0.55, −0.10)
k; *N*	9; 14,461	32; 17,157	22; 13,954	9; 20,663	28; 17,849	17; 15,880	14; 9,275
Safety climate							
r, r_c	−.18, −.37	.54, .80	.53, .71	.57, .70	−.19, −.24	−.29, −.38	−.30, −.45
95% CI	(−0.62, −0.11)	(0.56, 1.00)	(0.64, 0.78)	(0.59, 0.81)	(−0.30, −0.17)	(−0.45, −0.31)	(−0.54, −0.35)
90% CV	(−1.00, 0.33)	(−0.39, 1.00)	(0.40, 1.00)	(0.35, 1.00)	(−0.49, 0.02)	(−0.59, −0.17)	(−0.81, −0.08)
k; *N*	18; 10,049	58; 58,118	47; 46,715	23; 22,367	45; 19,295	23; 31,484	34; 28,307

Note. 95% CI = 95% confidence interval around r_c; 90% CV = 90% credibility interval around r_c.

Table 3
Relationship of Burnout, Engagement, and Safety Outcomes

		Engagement			Safety outcomes	
Variable	Burnout	Engagement	Compliance	Satisfaction	Accidents and injuries	Adverse events
Engagement						
Engagement						
r, r_c	−.19, −.25					
95% CI	(−0.41, −0.09)					
90% CV	(−0.53, 0.03)					
k; N	8; 2,054					
Compliance						
r, r_c	−.17, −.22	.44, .61				
95% CI	(−0.36, −0.08)	(0.56, 0.65)				
90% CV	(−0.42, −0.03)	(0.44, 0.78)				
k; N	5; 3,791	32; 38,487				
Satisfaction						
r, r_c	−.26, −.30	.48, .58	.33, .46			
95% CI	(−0.49, −0.11)	(0.47, 0.69)	(0.35, 0.57)			
90% CV	(−0.59, −0.01)	(0.33, 0.83)	(0.25, 0.67)			
k; N	6; 2,758	14; 3,505	10; 4,509			
Safety outcomes						
Accidents and injuries						
r, r_c	.11, .13	−.06, −.08	−.16, −.20	−.08, −.11		
95% CI	(0.05, 0.21)	(−0.18, 0.02)	(−0.27, −0.12)	(−0.17, −0.05)		
90% CV	(−0.01, 0.28)	(0.31, 0.15)	(−0.43, 0.04)	(−0.26, 0.05)		
k; N	9; 3,964	13; 7,447	24; 10,191	16; 32,738		
Adverse events						
r, r_c	.24, .29	−.22, −.32	−.33, −.49	−.23, −.29	.39, .51	
95% CI	(0.18, 0.40)	(−0.41, −0.22)	(−0.57, −0.41)	(−0.36, −0.22)	(0.40, 0.62)	
90% CV	(0.07, 0.52)	(−0.51, −0.13)	(−0.66, −0.32)	(−0.35, −0.22)	(0.22, 0.80)	
k; N	10; 12,144	9; 26,285	12; 25,628	4; 1,409	18; 5,918	
Unsafe behavior						
r, r_c	.25, .32	−.22, −.28	−.28, −.39	−.14, −.20	.20, .24	.04, .09
95% CI	(−0.12, 0.76)	(−0.41, −0.15)	(−0.49, −0.28)	(−0.37, −0.02)	(0.11, 0.37)	(−0.16, 0.35)
90% CV	(−0.17, 0.81)	(−0.66, 0.10)	(−0.68, −0.09)	(−0.38, −0.02)	(−0.08, 0.56)	(−0.27, 0.46)
k; N	3; 2,409	20; 22,424	19; 13,512	4; 437	16; 5,382	5; 2,592

Note. 95% CI = 95% confidence interval around r_c; 90% CV = 90% credibility interval around r_c.

sum to R^2. Thus, relative importance can be expressed as the proportion of variance each variable explains. When predictor variables are correlated, however, these indices are considered inadequate for determining the relative importance of predictor variables because the indices are no longer equivalent, do not sum to R^2, and take on different meanings (Budescu, 1993; Darlington, 1968; Johnson, 2001; Tabachnick & Fidell, 2001).

A common way of determining relative importance when predictors are correlated is through the use of epsilon (Johnson, 2000). The epsilon statistic was designed to furnish meaningful estimates of relative importance in the presence of correlated predictors. The estimates derived from epsilon, often labeled relative weights, sum to the model R^2. Thus, the relative weights represent the proportionate contribution each predictor makes to R^2, given the direct effect of the predictor and its effect when combined with other predictors. Researchers can also calculate the percentage of R^2 explained by each predictor by dividing the relative weight of each predictor by the total R^2. Because of these attributes, epsilon is a preferred statistic for computing relative importance (Johnson & Lebreton, 2004; Lebreton, Binning, Adorno, & Melcher, 2004). Given the fact that many of the variables in our model are highly correlated (e.g., r_c = .57 for knowledge–safety climate; r_c = .80 for social support–safety climate), we chose to use the epsilon statistic to examine relative importance.

Table 4 provides the percentage of R^2 explained in burnout, engagement, and safety outcomes by job demands and resources.

Table 4
Relative Importance of Job Demands–Job Resources in Predicting Burnout, Engagement, and Safety Outcomes

Variable	Burnout	Engagement			Safety outcomes		
		Engagement	Compliance	Satisfaction	Accidents and injuries	Adverse events	Unsafe behavior
Job demands							
Risks and hazards	57.1*	60.9*	78.0*	1.8	50.0*	84.8*	2.2*
Physical demands	4.0	5.1	3.6*	60.5*	15.4*	3.6	25.0*
Complexity	38.9*	34.0*	18.4*	37.7*	34.6*	11.7*	72.8*
Job demands total R^2	.13	.61	.64	.28	.03	.20	.22
Job resources							
Knowledge	6.0*	10.9*	15.3*	3.9*	1.6*	3.3*	10.1*
Autonomy	36.6*	3.6*	3.3*†	3.9*	1.9*	30.7*	4.3*
Social support	9.5*	24.9*	29.1*	37.3*	65.5*	31.6*	15.5*
Leadership	25.0*	18.8*	18.3*	37.9*	15.5*	8.1*	20.3*
Safety climate	22.8*	42.0*	34.0*	17.0*	15.5*	26.2*	49.8*
Job resources total R^2	.23	.67	.58	.85	.32	.22	.21

Note. Values are $\%R^2$, unless otherwise specified. An asterisk indicates that the 95% confidence interval does not cross zero; a dagger indicates that percentage is based on $k = 1$.

Results indicate that largest percentage of variance in burnout was explained by risks and hazards (57.1%), followed by complexity (38.9%). The largest percentage of variance for engagement and compliance was explained by risk and hazards (60.9% and 78.0%, respectively), whereas the largest percentage of variance in satisfaction was explained by physical demands (60.5%). Risks and hazards explained the largest percentage of variance for accidents and injuries and for adverse events (50.0% and 84.8%, respectively), whereas complexity explained the largest percentage of variance in unsafe behavior (72.8%). The results of the relative importance analysis indicate that risks and hazards was the job demand that contributed the most to burnout, engagement, and safety outcomes.

In terms of job resources, results in Table 4 indicate that safety climate explained the largest percentage of variance in engagement (42.0%) and compliance (34.0%), followed closely by social support, which explained 24.9% of the variance in engagement and 29.1% of the variance in compliance. For satisfaction, leadership explained the largest percentage of variance (37.9%), followed closely by social support (37.3%). Results also demonstrated that the largest percentage of variance in burnout was explained by autonomy (36.6%), followed by leadership (25.0%) and safety climate (22.8%). For accidents and injuries, the largest percentage of variance was explained by social support (65.5%), followed by leadership and safety climate (15.5% for both). The largest percentage of variance in adverse events also was explained by social support (31.6%), followed closely by autonomy (30.7%) and safety climate (26.2%). For unsafe behavior, safety climate explained the largest percentage of variance (49.8%). The results of the relative importance analysis for job resources indicate that social support and safety climate are key job resources that contribute the most to burnout, engagement, and safety outcomes. Given the high correlation ($r_c = .80$) of social support and safety climate, it is perhaps difficult to discriminate between the two; thus, they may be best thought of as two facets of a supportive environment.

The results of the relative importance analysis of burnout and engagement in explaining variance in safety outcomes can be seen in Table 5. In all three categories of safety outcomes, burnout and compliance explained the largest percentage of variance. For accidents and injuries, compliance explained 62.3% and burnout explained 20.8% of variance. For adverse events, compliance explained 59.1% and burnout explained 18.1% of variance. Finally, for unsafe behavior, compliance explained 46.5% and burnout explained 34.3% of variance. Overall, the results indicate that compliance contributes the most to safety outcomes, but burnout also accounts for a substantial amount of variance in safety outcomes. Table 6 summarizes results of the correlation and relative importance analyses.

Mediation

Hypotheses 7a and 7b predicted that burnout would mediate the relationship between job demands and resources and safety outcomes, respectively. Hypothesis 8a and 8b predicted that engagement would mediate the relationship between job demands and resources and safety outcomes, respectively. In order to formally test these hypotheses, we estimated a meta-analytic path model including the job demand (i.e., risks and hazards), job resource (i.e., safety climate), and engagement (i.e., compliance) that explained the largest amount of variance in the mediators and/or

Table 5
Relative Importance of Burnout and Engagement in Predicting Safety Outcomes

Variable	Safety outcomes		
	Accidents and injuries	Adverse events	Unsafe behavior
Burnout	20.8*	18.1*	34.3
Engagement			
Engagement	7.5	12.7*	14.1*
Compliance	62.3*	59.1*	46.5*
Satisfaction	9.4*	10.1*	5.2*
Total R^2	.05	.28	.21

Note. Values are $\%R^2$, unless otherwise specified. An asterisk indicates that the 95% confidence interval does not cross zero.

Table 6
Summary of Relationships for JD-R Model in Context of Safety

Variable	Burnout	Engagement	Compliance	Satisfaction	Accidents and injuries	Adverse events	Unsafe behavior
Job demands							
Risks and hazards	+ + +	◇ ◇ ◇	◇ ◇ ◇		+ + +	+ + +	+
Physical demands			◇	◇ ◇ ◇	+		+ +
Complexity	+ +	◇ ◇	◇	◇ ◇	+ +	+	+ + +
Job resources							
Knowledge	◇	+	+	+	◇	◇	◇
Autonomy	◇ ◇	+		+	◇	◇ ◇	◇
Social support	◇	+	+ +	+ +	◇ ◇ ◇	◇ ◇	◇
Leadership	◇ ◇	+	+	+ +	◇	◇	◇
Safety climate	◇	+ +	+ +	+	◇	◇ ◇	◇ ◇
Burnout					+	+	
Engagement							
Engagement						◇	◇
Compliance					◇ ◇ ◇	◇ ◇ ◇	◇ ◇ ◇
Satisfaction					◇	◇	◇

Note. Includes only relationships in which 95% confidence interval does not cross zero. + or ◇ indicates direction of relationship, with + representing positive relationship and ◇ representing negative relationship. + + + or ◇ ◇ ◇ explains > 50% of variance; + + or ◇ ◇ explains 25%–49% of variance; + or ◇ explains 0%–24% of variance. JD-R model = job demands–resources model.

outcomes (see Figure 2). In the case of job resources, we chose to use safety climate versus social support, given that their correlation was high and that the larger number of studies included in safety climate would produce a more stable estimate. We input matrices of the relevant estimated true score correlations into LISREL 8.72 (Jöreskog & Sörbom, 2002).

We specified a model, consistent with the JD-R model, in which risks and hazards and safety climate related to burnout and compliance, which in turn related to accidents and injuries and adverse events (see Figure 2). In order to test mediation, we simultaneously tested the direct and indirect paths of the independent variables on the dependent variables. Mediation can be inferred from the test if the indirect path is significant. We also allowed the disturbance terms on accidents and injuries and adverse events to correlate, given that theoretically they represent a broader safety outcome construct and empirically they are highly correlated (r_c = .51).

Results of the structural model fit the data relatively well, $\chi^2(1) = 3.59$, CFI = .99, SRMR = .02, root mean square error of approximation (RMSEA) = .12. The relationship between safety climate and accidents and injuries was the only direct relationship between the independent and dependent variables that approached significance ($\beta = -.18$, $p < .10$). Therefore, we specified a second structural model, nested within the first, in which we eliminated the three other direct effects of the independent variables on the dependent variables but kept the direct path from safety climate to accidents and injuries. Results of this model showed a good fit, $\chi^2(4) = 7.07$, CFI = .99, SRMR = .02, RMSEA = .06. The fit of this model to the data is not significantly different from that of the first model, $\Delta\chi^2(3) = 3.48$, $p > .10$, and thus the second structural model is superior because it is more parsimonious and fits the data equally well.

The standardized path estimates from the model are depicted in Figure 2. Risks and hazards were significantly related to compliance ($\beta = -.51$). Safety climate was significantly related to compliance ($\beta = .41$), burnout ($\beta = -.32$), and accidents and injuries ($\beta = -.19$). Burnout was significantly related to adverse events ($\beta = .19$), as was compliance ($\beta = -.45$), but neither burnout nor compliance was significantly related to accidents and injuries.

Table 7 presents the results of the examination of the indirect effects. Neither the indirect path of risks and hazards nor that of safety climate to accidents and injuries was significant. The indirect path for risks and hazards to adverse events was significant ($\beta = .24$), as was the indirect path for safety climate to adverse events ($\beta = -.24$). Effects decomposition shows that compliance was the primary mediator, although a Sobel (1982) test of the indirect effect of safety climate on adverse events through burnout was significant ($p < .05$).[1] Based on these results, there was support for partial mediation for adverse events in Hypotheses 7b, 8a, and 8b. Although Hypothesis 7a was not supported in the results of the path model, meta-analytic regression results did find that burnout partially mediated ($p < .05$) the relationship between job demands and adverse events. Furthermore, although the effects of safety climate on adverse events were partially mediated by compliance and burnout, safety climate also had a direct effect on accidents and injuries.

Generalization Within and Across Industries

Our final analysis concerned the extent to which relationships of job demands and resources with burnout, compliance, and safety outcomes generalize across industry. Thus, we analyzed the relative importance of job demands and resources in predicting burn-

[1] The Sobel (1982) formula, in which the estimate of the mediation effect is divided by its standard error and this value is compared to a standard normal distribution, is the most commonly used method for testing the significance of the mediation variable effect. Simulation studies have found the Sobel method produces accurate estimates of the standard errors. Although it has less power than some methods, it also has more accurate Type I error rates than other methods. Thus, choosing other methods for determining statistical significance of the mediation variable is unlikely to change the results of the analysis (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002).

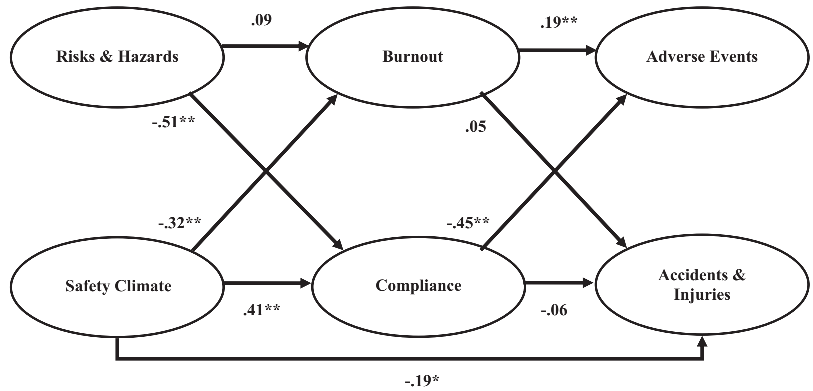

Figure 2. Hypothesized path model. Values represent standardized coefficients. $^{*}p < .05$. $^{**}p < .01$.

out and engagement (see Table 8) and the relative importance of job demands and resources, burnout, and engagement in predicting safety outcomes (see Table 9). To conduct this analysis, we constructed a separate meta-analytic correlation matrix for each of the four industries. Due to a low number of studies, we did not explore relationships with satisfaction and unsafe behavior. Furthermore, some relationships were not explored in a given industry and therefore are not shown in Tables 8 and 9. If a correlation between job demands and job resources was not studied in a particular industry, we estimated the correlation based on the average correlation across industries.

In terms of explaining variance in burnout, risks and hazards explained the largest percentage of variance across industries (see Table 4). When analyzed by industry, risks and hazards explained the largest percentage of variance only in construction (96.6%) and transportation (60.9%), where both had moderate effect sizes (r_c = .24, r_c = .39, respectively). Complexity explained the largest percentage of variance in health care (96.4%) and manufacturing/processing (89.5%; see Table 8), although the correlation was much stronger in the health-care industry than the manufacturing/processing industry (r_c = .41 vs. r_c = .19). As for job resources, across industries, autonomy, leadership, and safety climate explained the largest percentage of variance in burnout (see Table 4). Autonomy explained the largest percentage of variance in the construction industry (56.5%) and also had a moderate effect size (r_c = .40). The various forms of a supportive environment explained the largest amount of variance in the other industries, with moderate effect sizes (range $r_c = -.19$ to $r_c = -.52$).

Risks and hazards also explained the largest amount of variance in engagement and compliance across industries (see Table 4). The variance in engagement in the construction and transportation industries, however, was equally explained by risks and hazards and physical demands, although the effect size for risks and hazards–engagement relationship was much stronger in the transportation industry than in the construction industry ($r_c = -.47$ vs. $r_c = -.22$). Risks and hazards explained the largest amount of variance in engagement (64.8%) in the health-care industry, but complexity explained the largest amount of variance of engagement (70.0%) in the manufacturing/processing industry. Both risks and hazards and complexity had large effect sizes ($r_c = -.76$, $r_c = -.59$, respectively). Risks and hazards explained the largest percentage of variance in compliance across industries except in manufacturing/processing, where physical demands and complexity explained equal variance with moderate effect sizes ($r_c = -.40$ for both; see Table 8). Across industries, the different sources of a supportive environment explained the largest amount of variance in engagement and compliance (see Table 4). This was also consistent when analyzed by industry, where effect sizes were also large (average r_c = .62). The exception was knowledge, which explained a large amount of variance in engagement (22.2%) and compliance (29.1%) in the manufacturing/processing industry and also had large effect sizes (r_c = .56, r_c = .58, respectively). Knowledge also explained a large amount of variance in compliance (38.6%) and had a large effect size (r_c = .76) in the transportation industry (see Table 8).

Table 7
Indirect Relationships Through Burnout and Compliance

Relationship	Indirect effect (mediation by burnout and compliance)	Indirect effect through Burnout	Indirect effect through Compliance
Risks and hazards → accidents and injuries	.03	.00	.03
Risks and hazards → adverse events	$.24^{**}$	.01	.23
Safety climate → accidents and injuries	−.04	−.02	−.02
Safety climate → adverse events	$-.24^{**}$	−.06	−.18

$^{**}p < .01$.

Table 8
Relative Importance of Job Demands–Job Resources in Predicting Burnout and Engagement Across Industry

					Engagement							
	Burnout				Engagement				Compliance			
Variable	Const	Health	Manu	Trans	Const	Health	Manu	Trans	Const	Health	Manu	Trans
Risks and hazards												
%R^2	96.6*†	—	2.6	60.9*	47.1*†	64.8*	19.2*	47.8*	71.9*	67.8*†	2.3	100.0
r_c	.24	—	.02	.39	−.22	−.76	−.40	−.47	−.16	−.89	−.14	−.20
Physical demands												
%R^2	3.4†	3.6	7.9†	39.1*	52.9	18.8	10.8*	52.2*†	28.1	24.0	48.8*	—
r_c	.06	.11	−.07	.33	−.23	−.16	−.22	.50	−.11	−.08	−.40	—
Complexity												
%R^2	—	96.4*†	89.5*	—	—	16.4*	70.0*	—	—	8.2*	48.8*†	—
r_c	—	.41	.19	—	—	−.47	−.59	—	—	−.41	−.40	—
Job demands total R^2	0.06	0.17	0.04	0.20	0.09	1.00	0.46	0.67	0.03	1.00	0.39	0.04
Knowledge												
%R^2	5.7*†	3.2	18.3	—	10.6*	6.9*	22.2*	13.1	5.0*	3.6*	29.1*	38.6*†
r_c	−.14	−.05	−.02	—	.48	.35	.56	.14	.41	.28	.58	.76
Autonomy												
%R^2	56.5*†	—	24.6*	—	—	—	10.8*	2.4*	—	—	—	—
r_c	.40	—	−.42	—	—	—	.44	.18	—	—	—	—
Social support												
%R^2	13.3*†	40.2*†	16.0*†	85.1*†	49.3*†	29.4*	10.6*	5.2	23.3*†	28.2*	27.5*†	—
r_c	−.16	.26	−.46	−.52	.80	.70	.48	.12	.11	.69	.62	—
Leadership												
%R^2	—	34.1*	18.3*†	6.6*†	16.9*	32.3*	27.5*	44.4*	50.1*	32.5*	22.2*	20.4*†
r_c	—	−.46	−.47	−.20	.70	.70	.62	.67	.62	.69	.59	.60
Safety climate												
%R^2	24.5*	22.5*	22.9*†	8.3*	23.2*	32.3*	28.9*	34.9*	21.5*	35.6*	21.2*	41.0*
r_c	−.22	−.21	−.49	−.19	.68	.71	.65	.59	.53	.72	.61	.75
Job resources total R^2	0.68	1.00	0.52	0.29	0.88	0.57	0.51	0.93	0.79	0.58	0.50	0.71

Note. A dash indicates that relative importance could not be calculated due to low number or absence of studies. An asterisk indicates that the 95% confidence interval does not cross zero; a dagger indicates that percentage is based on $k = 1$.
[*] Const = construction; Health = health care; Manu = manufacturing/processing; Trans = transportation.

Risks and hazards explained the largest amount of variance in accidents and injuries and adverse events across industries (see Table 4). For accidents and injuries, this was also true in construction (61.0%) and transportation (50.0%), although the effect size in the construction industry was much stronger than in the transportation industry (r_c = .17 vs. r_c = .06). In the health-care industry, physical demands explained the largest amount of variance (52.0%) but had an effect size (r_c = .22) similar to that in transportation. Risks and hazards also explained the largest amount of variance in adverse events in construction (57.1%) and health care (72.6%), although the effect size was much stronger in the health-care industry than the construction industry (r_c = .45 vs. r_c = .18). Physical demands explained the largest amount of variance in the manufacturing/processing industry (54.4%) and had an effect size of r_c = .23 (see Table 9). The various forms of a supportive environment explained the largest amount of variance in accidents and injuries and adverse events across industries (see Table 4). This pattern was consistent in the industry analysis except in the construction and manufacturing/processing industries, where autonomy explained the largest amount of variance in adverse events (45.5% and 84.8%, respectively). Overall, effect sizes were moderate in terms of the relationship of the various forms of a supportive environment to accidents and injuries and adverse events.

Finally, we investigated the amount of variance in accidents and injuries and adverse events explained by burnout and engagement. Across industries, burnout and compliance explained the largest amount of variance in accidents and injuries and adverse events (see Table 5). When analyzed by industry, this pattern was also consistent, and the effect sizes were moderate (see Table 9). Overall, the results of the industry analysis demonstrate that the job demands that explain the most variance in burnout, engagement, and safety outcomes differ by industry, but that a supportive environment explains the most variance consistently across industries. Burnout and compliance also explain the most variance in all industries and thus may be the primary mechanisms through which job demands and resources influence safety outcomes.

Discussion

We sought to develop and meta-analytically test the link between job demands and resources and burnout, engagement, and safety outcomes in the workplace. Using the JD-R model (Bakker & Demerouti, 2007; Demerouti et al., 2001), we cate-

Table 9
Relative Importance of Job Demands–Job Resources, Burnout, and Engagement in Predicting Safety Outcomes Across Industry

	Safety outcomes							
	Accidents and injuries				Adverse events			
Variable	Const	Health	Manu	Trans	Const	Health	Manu	Trans
Risks and hazards								
%R^2	61.0*†	13.3†	66.7	50.0*	57.1*†	72.6*	2.6	—
r_c	.17	.07	.18	.06	.18	.45	.07	—
Physical demands								
%R^2	39.0*	52.0*	28.6*	50.0	42.9*†	21.5	54.4*	100.0
r_c	.14	.22	.14	.06	.16	.08	.23	.27
Complexity								
%R^2	—	34.7*	4.8†	—	—	6.0*	43.0*†	—
r_c	—	.20	−.02	—	—	.17	.20	—
Job demands total R^2	.04	.10	.04	.06	.05	.37	.11	.07
Knowledge								
%R^2	30.4*	4.3*	4.7*	9.7*	36.4*†	6.3*	6.9*	—
r_c	−.17	−.07	−.25	−.06	−.20	−.17	−.25	—
Autonomy								
%R^2	13.0*†	23.9*†	10.3†	—	45.5*†	20.0*†	84.8*†	—
r_c	−.14	−.23	.08	—	−.21	−.28	−.80	—
Social support								
%R^2	15.2*†	—	63.5*	—	6.1†	—	—	89.3*†
r_c	−.13	—	−.97	—	−.02	—	—	.56
Leadership								
%R^2	—	55.4*	9.8*	83.9*	—	12.1*	3.2*	—
r_c	—	−.29	−.40	−.16	—	−.20	−.21	—
Safety climate								
%R^2	41.3*	16.3*	11.7*	6.5	12.1†	61.6*	5.1*	10.7
r_c	−.20	−.20	−.34	−.02	−.07	−.40	−.27	.11
Job resources total R^2	.05	.09	1.00	.03	.10	.19	.71	.38
Burnout								
%R^2	80.3*	10.4	—	80.0*	72.9†	27.7*	—	100.0
r_c	.28	.07	—	.21	.33	.30	—	.19
Engagement								
%R^2	16.4*	22.6†	28.3	—	—	12.1*	22.0†	—
r_c	−.18	.02	−.21	—	—	−.33	−.18	—
Compliance								
%R^2	3.3*	67.0*	71.7*	20.0*	27.1*†	60.1*	78.0*	—
r_c	−.11	−.21	−.29	−.12	−.22	−.51	−.28	—
Burnout and engagement total R^2	.12	.11	.09	.05	.13	.40	.08	.04

Note. A dash indicates that relative importance could not be calculated due to low number or absence of studies. An asterisk indicates that the 95% confidence interval does not cross zero; a dagger indicates that percentage is based on $k = 1$. Const = construction; Health = health care; Manu = manufacturing/processing; Trans = transportation.

gorized the conditions related to workplace safety into job demands and job resources. We found, consistent with the JD-R model, that job demands such as risks and hazards and complexity impair employees' health and lead to burnout. Likewise, we found support for job resources such as knowledge, autonomy, and a supportive environment motivating employees toward higher engagement. Job demands were also found to hinder an employee's progress toward engagement, whereas job resources were found to mitigate burnout. Finally, we found that burnout was detrimental to working safely but that engagement motivated employees toward working safely. Tests of mediation suggest that the health impairment process and the motivational process proposed by the JD-R model are both mechanisms through which job demands and resources influence safety outcomes.

We also examined which job demands and resources contribute the most to burnout, engagement, and safety outcomes. We found that across industries, risks and hazards was the most consistent job demand in terms of explaining variance in burnout, engagement, and safety outcomes. A supportive environment, whether from social support, leadership, or safety climate, was also consistent in explaining variance across these same outcomes. When analysis was by industry, we did find that the type of job demand that explained the most variance differed by industry, whereas a supportive environment remained consistent in explaining the most variance in all industries.

Theoretical Contributions

Our research makes three important theoretical contributions. First, by drawing from the JD-R model we were able to provide an integrative theoretical framework that can account for the various job demands and resources present in the working environment and their relationship to safety outcomes. This allowed us to investigate the health impairment and motivational processes through which job demands and resources relate to workplace safety, which have not been explored in past meta-analytic summaries. We found support for both processes. Job demands were positively related to burnout, which in turn was positively related to accidents and injuries and adverse events, reflecting a health impairment process. Job resources were positively related to engagement, which in turn was positively related to safety outcomes, reflecting a motivational process.

Second, we are the first to examine the relative importance of the factors related to workplace safety. Although there are a variety of job demands and resources, we were able to identify which particular job demand and job resource contributed the most to burnout, engagement, and safety outcomes. This is an important contribution, as executives believe the best way to improve safety is through providing relevant training (Huang, Leamon, Courney, Chen, & DeArmond, 2007). The results of our study suggest that reducing risks and hazards and establishing a supportive environment are among the best ways to improve safety.

Third, the current study clarifies potential questions regarding construct validity in the safety literature. The first relates to the discriminant validity of the constructs of engagement, compliance, and unsafe behavior. As the JD-R model suggests, employee engagement and compliance represent two forms of engagement. We found that these two constructs are related (r_c = .57) and that job demands and resources explain relatively equal amount of variance in engagement and compliance. Compliance, however, explains the largest amount of variance in safety outcomes, demonstrating that compliance is a key engagement construct in the JD-R model. Unsafe behavior is categorized as an outcome under the JD-R model and showed only moderate relationships with engagement and compliance, thus demonstrating it is a separate construct both theoretically and empirically.

The second question regarding construct validity is the discriminant validity of safety climate. One of the job resources is a supportive environment, which can be further delineated in terms of the source of the support, whether from the broader social environment, leadership, or safety climate. The JD-R model categorizes all of these as job resources, and empirically we found the constructs to be highly related to one another (range r_c = .69 to r_c = .80). Although there were differences in terms of which form of a supportive environment explained the most variance in safety outcomes, we believe that organizations would best improve safety by creating a supportive environment that encompasses all sources of support rather than focusing on the various forms of a supportive environment.

The third construct validity question relates to the predictive validity of job demands, job resources, burnout, and engagement. We found that job demands explained relatively little variance in accidents and injuries (R^2 = .03) compared to job resources (R^2 = .32) but that job demands and resources explained a similar amount of variance in adverse events (R^2 = .20 and R^2 = .22, respectively). Burnout and engagement explained a small amount of variance in accidents and injuries (R^2 = .05) compared to adverse events (R^2 = .28). The mediation analysis showed that the relationship of risks and hazards to adverse events was mediated through compliance, and that burnout and compliance mediated the relationship between safety climate and adverse events. Safety climate was also found to have a direct relationship with accidents and injuries. Thus, it appears job demands hinder employee compliance, whereas job resources enhance employee motivation to comply and mitigate burnout. Accidents and injuries, however, may be best prevented by job resources such as a supportive environment.

Practical Implications

Our results have important practical implications for organizations. First, we found that risks and hazards, physical demands, and complexity relate to burnout, engagement, and safety outcomes but that risks and hazards is the key job demand in terms of explaining the most variance. This suggests that organizations would benefit from performing risk assessments in order to find ways to mitigate or avoid the risks and hazards inherent in their particular setting. Although risks and hazards were important across industries, there was variability in the importance of the other job demands across industries. This suggests that managers could use our results to identify which job demands are the most important in their particular setting and use that information as a starting point in designing targeted interventions.

Second, although executives believe training is the key safety intervention (Huang et al., 2007), our results suggest that organizations should consider creating a supportive environment for employees. Organizations can develop this supportive environment by training supervisors to be better leaders, emphasizing the importance of teamwork and social support, and establishing the value of safety. Our results demonstrate that establishing a supportive environment will benefit organizations across industries.

Third, the study suggests the importance of recognizing that job demands and resources have broader implications than safety outcomes. Job demands exhaust employees, lead to burnout, and hinder engagement. Fortunately, job resources motivate employees towards engagement and mitigate burnout. By creating a supportive environment, organizations are not just achieving a safe workplace but are potentially increasing the motivation and health of their employees.

Comparison to Previous Meta-Analyses

The most recent quantitative summary of the safety literature focused on the person- and situation-based antecedents of safety (Christian et al., 2009). Our findings differ in three important ways. First, Christian et al. did not include articles in which the job or outcome was driving related, nor did they include unpublished studies. We addressed these important limitations. As a result, our research includes more than twice as many independent samples as theirs did and offers the most complete and accurate estimates of safety-related relationships. By excluding driving-related jobs and outcomes, Christian et al. omitted the majority of research conducted in the transportation industry. This omission is notable because we found that risks and hazards are particularly important in terms of explaining variance in engagement and accidents and injuries in the transportation industry. This finding contrasts with research that has shown relatively weak relationships for these same constructs. We also found that the largest amount of variance in accidents and injuries in the transportation industry is explained by leadership rather than safety climate, which is another key difference from past research (Christian et al., 2009). Thus, the comprehensiveness of our review allowed us to explore the relationships across all industries and discover that there were indeed important differences across industries.

Second, it has been suggested that safety knowledge is more strongly related to compliance and participation than is safety climate (Christian et al., 2009). Although we also found that knowledge and safety climate were positively related to compliance and engagement (which includes participation), the results of our relative importance analysis suggest that safety climate, rather than knowledge, was the job resource that explained the largest amount of variance in compliance and engagement. The results of these analyses are important because the use of the epsilon statistic takes into account the correlation between the two predictors (Johnson, 2000). Given that knowledge and safety climate are positively related ($r_c = .57$), it is important to take into account the proportionate contribution each makes to the total variance explained, when each of their direct effects and their effect when combined are considered.

Third, previous investigations excluded complexity and burnout (Christian et al., 2009), which were found to be important constructs in the current study. Although risks and hazards was a consistent job demand in relation to burnout, engagement, and safety outcomes, in certain industries, such as health care and manufacturing/processing, complexity explained a large amount of variance in these outcomes. By including burnout, we were able to examine the health impairment process in which job demands can deplete an employee's mental and physical resources. Because existing safety performance models (Christian et al., 2009; Neal & Griffin, 2004) primarily focus on motivational processes, they neglect a potentially important pathway through which elements of the work environment can impact safety performance. Results of the current study show that job demands are positively related to burnout and that burnout explains a large amount of variance in safety outcomes.

Limitations and Future Research

There are several limitations associated with the current study. First, relatively few studies have been conducted for many of the relationships examined. Thus, we provide preliminary results of these relationships. In particular, although burnout was found to be positively related to accidents and injuries and adverse events, relatively few studies have examined these relationships. Future research should examine the relationship of job demands and resources with burnout and the relationship of burnout to safety outcomes. Furthermore, given that autonomy has long been discussed as a key job resource (Karasek, 1979), future research should investigate the relationship of autonomy to burnout, engagement, and safety outcomes. Second, the low number of studies for some constructs limited our moderator analyses. Although we investigated the extent to which the relationships generalized across industries, many estimates were based on a relatively few studies. Given that the contribution of job demands differed across industries, future research should investigate the JD-R model in all industries.

Third, several limitations in the use of meta-analytic correlation matrices with regard to path analyses have been noted and investigated by researchers (Field, 2005; Furlow & Beretvas, 2005; Hafdahl, 2007; Hafdahl & Williams, 2009). These limitations primarily focus on the accuracy of parameter estimates and goodness-of fit-indices. One concern is that different studies contribute to different cells in the matrix, which is analogous to missing data at the subject level in primary studies. For example, in the current study, the meta-analytic correlation for the relationship between complexity and burnout is obtained from studies that are different from the studies that are utilized to obtain the meta-analytic correlation for the relationship between physical demands and burnout. Research has found parameter estimates and chi-square tests to be biased when data in a meta-analytic matrix are missing not at random (Furlow & Beretvas, 2005). Thus, if effect sizes are missing not at random, the results may be subject to bias (Naragon-Gainey, 2010). Although we utilized all effect sizes that contributed to a particular cell, there is the potential for this bias to be present in our meta-analytic path analysis results as well. This potential limitation should be kept in mind when interpreting these results.

Finally, most workplace safety research has involved evaluating all of the factors from the employee's perception. Job demands, job resources, burnout, and engagement were often assessed from the same source. Thus, the studies suffer from common method bias that potentially inflated the relationships between constructs. This is a well-known problem (Crampton & Wagner, 1994; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003), and meta-analyzing data does not remove these flaws. Related to this, because most constructs were assessed from the same source and at the same time, it is impossible to draw strong causal inferences from the current study. Future research should not only incorporate ratings from multiple sources but also include experimental or longitudinal research to help clarify causality.

These limitations notwithstanding, we believe that considering both the health impairment process and the more traditionally investigated motivational process has provided a richer and broader investigation of how the organizational context impacts safety outcomes. We have highlighted the important role that burnout plays as a mechanism through which job demands and resources relate to safety outcomes and hope this will lead to further investigations of the health impairment process.

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Received August 22, 2008
Revision received August 13, 2010
Accepted August 23, 2010 ■