Article

Organizational Psychology Review

Organizational Psychology Review
2016, Vol. 6(4) 352–381

DOI: 10.1177/2041386615626243
opr.sagepub.com
SAGE

Workplace safety: A review and research synthesis

Jeremy M. Beus
Louisiana State University, USA

Mallory A. McCord
University of Central Florida, USA

Dov Zohar
Technion – Israel Institute of Technology, Israel

Abstract

Unsafe work environments have clear consequences for both individuals and organizations. As such, an ever-expanding research base is providing a greater understanding of the factors that affect workplace safety across organizational levels. However, despite scientific advances, the workplace safety literature suffers from a lack of theoretical and empirical integration that makes it difficult for organizational scientists to gain a comprehensive sense of (a) what we currently know about workplace safety and (b) what we have yet to learn. This review addresses these shortcomings. First, the authors provide a formal definition of workplace safety and then create an integrated safety model (ISM) based on existing theory to summarize current theoretical expectations with regard to workplace safety. Second, the authors conduct a targeted review of the safety literature and compare extant empirical findings with the ISM. Finally, the authors use the results of this review to articulate gaps between theory and research and then make recommendations for both theoretical and empirical improvements to guide and integrate future workplace safety research.

Keywords

Accidents, high reliability organization, safety, safety climate, safety model

In 2013, an average of 12 people in the U.S. private sector went to work each day and never came home because of on-the-job fatalities; an additional 2,500 workers per day sustained injuries or illnesses on the job that caused them to miss subsequent work days (Bureau of Labor

Paper received 29 April 2015; revised version accepted 16 December 2015.

Corresponding author:
Jeremy M. Beus, Rucks Department of Management, Louisiana State University, Baton Rouge, LA 70803, USA.
Email: jbeus@lsu.edu

Statistics, U.S. Department of Labor, 2015). The collective financial toll of such safety incidents is estimated to cost U.S. employers approximately $1 billion per week (Occupational Safety & Health Administration, 2015). This is in addition to the more immediate individual (e.g., bodily harm) and organizational consequences (e.g., productivity loss) associated with such workplace incidents. Recent high-profile workplace safety incidents likewise draw attention to the myriad consequences associated with unsafe workplaces (e.g., Deep Water Horizon oil spill, "Deepwater Horizon Owner," 2011; Texas fertilizer plant explosion, Schneyer, McNeill, & Roberts, 2013; Turkey mine disaster, Tuysuz, Watson, & Smith-Spark, 2014).

There is undoubtedly much to gain from attaining a clearer understanding of the factors that affect workplace safety. Although organizational scientists have long recognized this, there has been a noteworthy increase in research attention on the subject of workplace safety in recent years. This is evidenced by several recent meta-analyses which have provided population estimates of key relationships relevant to workplace safety (e.g., Beus, Dhanani, & McCord, 2015; Beus, Payne, Bergman, & Arthur, 2010; Burke et al., 2011; Christian, Bradley, Wallace, & Burke, 2009; Clarke, 2012; Clarke & Robertson, 2005; Nahrgang, Morgeson, & Hofmann, 2011). However, although these meta-analyses provide important overviews of the existing research base, there remains a need to further synthesize extant empirical findings to gain a more comprehensive understanding of (a) what the field of workplace safety has accomplished, and (b) what the field has yet to accomplish. The purpose of this review is to address both of these objectives.

Although past reviews of the workplace safety literature have worked to achieve these objectives in some measure (e.g., Burke & Signal, 2010; Kaplan & Tetrick, 2011; Wallace, Paul, Landis, & Vodanovich, 2012), we build and expand upon these existing reviews—as well as current meta-analyses—in several important ways. First, we provide an explicit conceptual definition of the construct of workplace safety which we use to establish a foundation for this review and to draw distinctions between commonly considered safety criteria. Second, we compare the extent to which current theory in workplace safety research corresponds with empirical findings. To do so, we integrate several theoretical models of workplace safety from seminal papers in the field to form an overarching conceptual model that represents current theoretical expectations concerning workplace safety. We then use this integrated model as a reference point for reviewing empirical papers to gauge the extent to which evidence exists to support this model. Finally, we use the results of our search to delineate gaps or inadequacies in our current knowledge of workplace safety relative to the integrated safety model as a structured means of articulating directions for future research.

Defining workplace safety and its indicators

Safety is almost universally left undefined in the organizational sciences and elsewhere; therefore, a formal definition of workplace safety is necessary for theoretical clarity. Using the literature on high-reliability organizations as a conceptual basis (see Bigley & Roberts, 2001; Hofmann, Jacobs, & Landy, 1995; Weick, Sutcliffe, & Obstfeld, 1999), we define workplace safety as an attribute of work systems reflecting the (low) likelihood of physical harm—whether immediate or delayed—to persons, property, or the environment during the performance of work. However, for the purposes of this review, we restrict our focus to personal safety (excluding property and environmental safety) both to manage the scope of this review and to be consistent with the meta-analyses and conceptual papers that form this paper's theoretical basis. Although the concept of personal safety likewise applies

to the likelihood of psychological harm (e.g., psychological safety; Edmondson, 1999) and intentional physical harm (e.g., violence, sabotage) when considered more broadly, we limit our consideration of safety here to the likelihood of *unintended physical harm to persons*.

Our working definition of safety has implications for the extent to which conventional safety indicators constitute adequate construct representations. Perhaps the most commonly examined workplace safety indicator is the occurrence of accidents (Wallace et al., 2012), which we define here as workplace events that result in physical harm to persons. Whereas accidents clearly indicate the absence of safety, a lack of accidents cannot necessarily be used to infer the *presence* of safety (i.e., a low likelihood of experiencing physical harm). This is because such incidents are generally contingent upon a multitude of factors (e.g., unsafe behaviors, latent organizational weaknesses) that often do not coincide to result in an accident (Reason, 1990). For example, workers who routinely ignore certain safety protocol will often do so precisely because it has yet to result in an accident (or because it rarely does). However, the absence of accidents in an organization with workers who disregard safety protocol clearly does not provide evidence to suggest the *presence* of safety. Rather, the negligent behavior reflects a state of limited freedom from harm that simply has yet to coincide with a set of circumstances to cause a more obvious lack of safety (i.e., an accident). Workplace accidents are thus deficient as indicators of workplace safety because they can only be used to indicate the absence, not the presence, of safety.

Conversely, safety-related work behaviors are more accurate workplace safety indicators because they can be used to infer both the absence and presence of safety. Consistent with our working definition of safety, we define safety-related behaviors as any workplace behaviors that affect the likelihood of physical harm to persons. Whereas *safe* work behavior (e.g., compliance, participation; Griffin & Neal, 2000) implies a reduced likelihood of future harm (i.e., the presence of safety), *unsafe* work behavior—whether intentional or unintentional—implies a greater likelihood of future harm (i.e., the absence of safety). We consider safety-related behaviors to be leading indicators of safety because they can communicate the absence of safety *before* actual damage is caused by an accident. Accidents on the other hand, are considered lagging indicators of safety because they only reflect the absence of safety *after* damage has already occurred. Safety-related behaviors are thus more proximal indictors of workplace safety than accidents because it is safety-related behaviors (among other factors) that generally precede the occurrence of accidents (Burke & Signal, 2010; Christian et al., 2009; Neal & Griffin, 2004; Zohar, 2011).

In sum, although both safety-related behaviors and accidents provide relevant information about workplace safety, safety-related behaviors are more informative from both theoretical and practical perspectives given that they more fully represent the construct of safety and can be used as proximal indicators that diagnose a lack of safety before actual damage is caused. Consequently, we place primary emphasis on safety-related behavior as an indicator of workplace safety for the purposes of this review (though we still consider the role of accidents in workplace safety theory and research). Although we depict safety-related behavior broadly in our integrated theoretical model, we make distinctions where possible between these behaviors using Griffin and Neal's (2000) widely accepted dimensions of safety compliance and safety participation. Safety compliance involves carrying out rule-prescribed safety activities to maintain workplace safety (e.g., wearing protective equipment, following safety procedures) whereas safety participation consists of discretionary behaviors that likewise impact workplace safety, though often indirectly (e.g., attending safety meetings, assisting coworkers under risky conditions). In

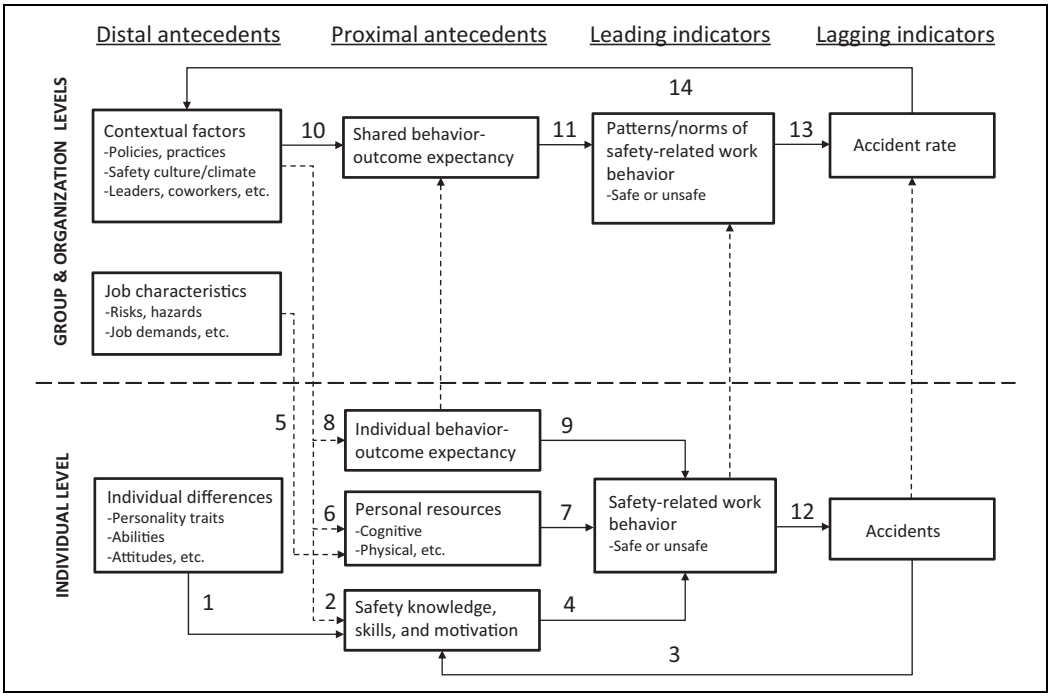

Figure 1. Integrated safety model: A summary of current workplace safety theories.
Dotted arrows represent cross-level relationships; nonnumbered dotted arrows are used to indicate aggregate or emergent processes between individual-level constructs and their group-level manifestations; core sources for these links are: Burke and Signal (2010, Links 1, 2, 3, 4, 12); Christian et al. (2009, Links 1, 2, 4, 12); Nahrgang et al. (2011, Links 5, 6, 7, 12); Neal and Griffin (2004, Links 1, 2, 4, 12); and Zohar (2011, Links 8, 9, 10, 11, 12, 13, 14).

addition to these dimensions of safety-related behavior, we likewise distinguish unsafe behaviors where necessary and emphasize that these can be either intentional or unintentional (Wiegmann & Shappell, 2003). We next present an integrated model of workplace safety that delineates both distal and proximal antecedents of safety-related work behavior and which provides the conceptual framework that is the basis for this review.

An integrated model of workplace safety

A number of conceptual models have been established by safety scholars in recent years to guide empirical research. These models have provided varying theoretical perspectives for understanding workplace safety. Although we believe these perspectives are cumulatively useful in improving safety knowledge, the growing number of models across a variety of publication outlets paints a fragmented picture of the workplace safety literature that is in need of unification. Consequently, we sought to create unity by combining the unique theoretical propositions of several models into a single, integrative safety model (ISM) that offers an overarching summary of extant theory concerning workplace safety. The ISM is depicted in Figure 1 and integrates theoretical propositions from five seminal works (i.e., Burke & Signal, 2010; Christian et al., 2009; Nahrgang et al., 2011; Neal & Griffin, 2004; Zohar,

2011). The ISM takes a multilevel perspective and differentiates between distal (e.g., individual differences, contextual factors) and proximal antecedents (e.g., safety knowledge, skills, or motivation) of safety-related behaviors and subsequent accidents across individual and group levels of analysis. To further illustrate the existence of multilevel processes using the ISM, we added nonnumbered links from individual-level constructs to their aggregate group-level manifestations to convey the presence of emergent processes regarding workplace safety (e.g., safety-related behavior to group-level patterns of safety-related behavior).

The ISM is meant to represent current thinking with regard to workplace safety. As such, we emphasize that it is neither *our* model, nor is it necessarily a definitive or complete depiction of the nomological net for this research domain. We discuss potential theoretical improvements for this model in the Discussion section. We likewise emphasize that the ISM does not necessarily reflect extant empirical findings. Whereas some of the depicted linkages are supported by meta-analytic estimates (e.g., 2, 5, 7, 12), others have received only preliminary empirical consideration (e.g., 3, 8, 9, 10, 11). Thus, the benefit of using the ISM as a framework to guide this review is that it provides a basis for determining how well evidence supports current conceptual models. In addition, the ISM facilitates the identification of knowledge gaps to focus researchers' attention on those areas that are in need of empirical substantiation.

A review and synthesis of empirical workplace safety research

In order to compare empirical findings against the proposed linkages in the ISM, we conducted a targeted search of journals in the organizational sciences to identify relevant studies. Specifically, we searched select journals in psychology and management, as well as the field of occupational safety, using the keywords "safety," "accident," "injury," "hazard," and "high reliability organizations." We limited our searches to papers published between 1980 and 2015 for the psychology and management journals and from 2000 to 2015 for the occupational safety journals. We restricted the scope of our searches to these date ranges to make the review more manageable while simultaneously ensuring that the most up-to-date research developments were included. We then determined whether the papers gleaned from search results were relevant for the proposed review. Articles were judged to be relevant if they quantitatively or qualitatively analyzed data to address questions germane to individual or group safety at work. This excluded conceptual or review papers, articles that studied safety in nonwork settings, or articles that examined psychological or emotional safety. Our search resulted in a total of 697 research articles pertaining to workplace safety, with 189 published in the selected psychology and management journals and 508 published in the selected occupational safety journals. A list of the journals searched for this review and the number of empirical workplace safety-related articles identified in each is reported in Table 1.

In the structured review that follows, we systematically summarize research from these journals relating to each of the linkages within the ISM. To summarize this research in an organized fashion, we dissected the ISM into distinct causal sequences based on the different theoretical approaches for explaining workplace safety. Discussion of these causal sequences and summaries of research pertaining to the elemental linkages of each sequence are divided into separate subsections in this paper. The theoretical perspectives that distinguish these causal sequences are job performance theory (Campbell, McCloy, Oppler, & Sager, 1993), the job demands-resources model (Bakker & Demerouti, 2007; Demerouti, Bakker, Nachreiner, & Schaufeli, 2001), and organizational climate theory (Zohar,

Table 1. Journals searched for workplace safety articles.

Journal	Articles
Psychology and management (1980–2015)	
Academy of Management Journal	11
Administrative Science Quarterly	4
Human Relations	4
Human Resource Management	2
Journal of Applied Psychology	43
Journal of Business and Psychology	10
Journal of Management	1
Journal of Managerial Psychology	0
Journal of Occupational and Organizational Psychology	15
Journal of Occupational Health Psychology	48
Journal of Organizational Behavior	6
Journal of Vocational Behavior	1
Leadership Quarterly	0
Organization Science	2
Organizational Behavior and Human Decision Processes	7
Personnel Psychology	6
Strategic Management Journal	1
Work & Stress	28
Occupational safety (2000–2015)	
Accident Analysis & Prevention	104
Journal of Safety Research	160
Safety Science	244
Total	697

Note. These journals were selected for this review because they represent high-visibility journals that have published or were expected to have published workplace safety research; these journals were searched using the keywords "safety," "accident," "injury," "hazard," and "high reliability organizations." Psychology and management journals were searched for articles published from 1980 to 2015 and occupational safety journals were searched for articles published from 2000 to 2015 to make the scope of this review more manageable.

2011; Zohar & Hofmann, 2012). We begin our review by summarizing the causal sequence associated with job performance theory.

Causal sequence explained by job performance theory

Based on Campbell et al.'s (1993) theory of job performance, Neal and Griffin (2004) theorized that the core individual determinants of safety-related behavior—like job performance—are individuals' safety-related knowledge, skills, and motivation. Also consistent with Campbell et al., Neal and Griffin proposed that these determinants are each a function of individual differences (e.g., ability, personality) and the organizational context (e.g., safety climate, leadership). Other safety researchers have theorized similar causal sequences (e.g., Burke & Signal, 2010; Christian et al., 2009), positing that individual differences (Linkage 1), contextual factors (Linkage 2), and personal experiences (Linkage 3) should affect safety knowledge, skills, and motivation which should in turn influence individuals' safety-related work behaviors (Linkage 4). This causal sequence based on job performance theory is depicted in Figure 2.

Linkage 1. In accordance with job performance theory, Linkage 1 posits that safety-relevant individual differences are key determinants of individual safety knowledge, skills, and motivation (Neal & Griffin, 2004). However, relatively few studies were located that tested these associations. Rather, research has tended to focus on the direct, unmediated associations between individual differences and safety-related behavior. For example, a recent meta-analysis by Beus et al. (2015) estimated direct population relationships between the five-factor model (FFM) personality traits and safety-related behavior (coded in the direction of unsafe behavior), with agreeableness ($\rho = -.26$, $k = 12$, 95% CI [−.32, −.19]) and conscientiousness ($\rho = -.25$, $k = 16$, 95% CI [−.35, −.15]) revealing the strongest associations. Though these traits revealed the strongest associations with safety-related behavior relative to the other FFM traits, it is perhaps noteworthy that the effect sizes are still small to moderate in magnitude. Outside of the simultaneous influence of contextual factors which tend to have a stronger impact on safety-related behavior (Beus et al., 2015), the comparably

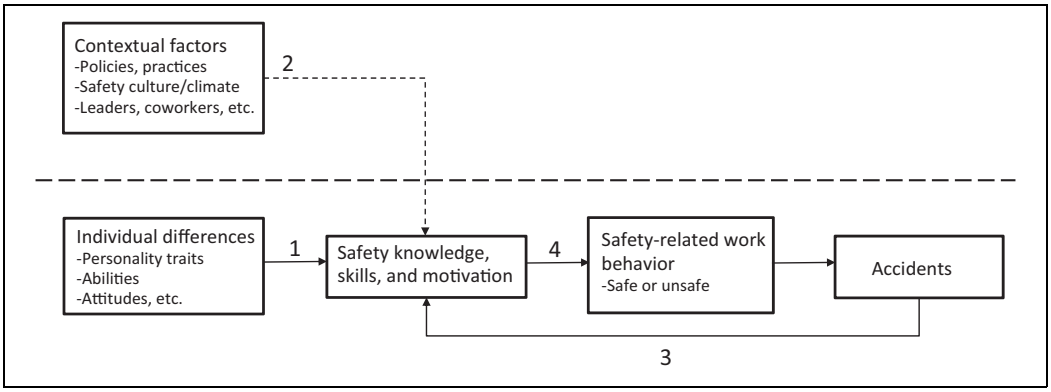

Figure 2. Causal sequence explained by job performance theory.
Dotted arrows represent cross-level relationships. Although the link between safety-related work behavior and accidents is displayed in this sequence for completeness, it is reviewed elsewhere (see Figure 5).

small magnitude of personality's associations with safety-related behavior may be because these relationships are mediated by the more proximal outcomes of safety knowledge, skills, and motivation as posited by job performance theory.

Of the few studies that explicitly tested safety knowledge, skills, or motivation as proximal outcomes of individual differences (e.g., Fruhen, Mearns, Flin, & Kirwan, 2013), the majority tested safety motivation as the dependent variable (e.g., Newman, Griffin, & Mason, 2008; Wallace & Chen, 2006; Westaby & Lowe, 2005). These studies indicate that whereas the individual characteristics of conscientiousness, self-efficacy, and safety attitudes are positively associated with safety motivation (Christian et al., 2009; Newman et al., 2008; Wallace & Chen, 2006), risk-taking tendencies are negatively associated with safety motivation (Westaby & Lowe, 2005). Nevertheless, much more research is needed to consider a broader range of safety-related individual differences (e.g., other personality traits, physical or mental ability) and to place greater emphasis on safety knowledge and skills as dependent variables in order to solidify this conceptual linkage.

Linkage 2. In addition to individual differences, contextual factors are likewise theorized to directly affect individual safety knowledge, skills, and motivation (Burke & Signal, 2010; Neal & Griffin, 2004). Examples of contextual factors that have been tested include safety leadership, safety norms, safety climate, and organizational safety training. Although the causal variables in this linkage fundamentally exist at group levels, the majority of studies have tested this linkage by relating individuals' perceptions of group phenomena (e.g., safety climate perceptions) to individual safety knowledge and motivation; few have directly tested for cross-level effects using group-level independent variables (e.g., safety climate; cf. Neal & Griffin, 2006).

At the individual level of analysis, multiple studies have reported positive relationships between individuals' perceptions of safety leadership and both individual safety knowledge (e.g., Barling, Loughlin, & Kelloway, 2002; Kelloway, Mullen, & Francis, 2006) and safety motivation (e.g., Conchie, 2013; Kath, Magley, & Marmet, 2010; Newman et al., 2008; Westaby & Lowe, 2005). Perceived coworker safety norms have likewise been positively linked with safety motivation (Rickett, Orbell,

& Sheeran, 2006). Similarly, individual-level safety climate—individuals' perceptions of safety's workplace priority (Zohar, 2011)—has consistently revealed positive associations with individual safety knowledge and motivation (Christian et al., 2009). The few existing cross-level studies have likewise revealed positive associations between group-level safety climate and individual-level safety motivation (Kark, Katz-Navon, & Delegach, 2015; Neal & Griffin, 2006; Wallace & Chen, 2006).

With regard to the influence of organizational safety training as a contextual safety antecedent, Burke et al.'s (2011) meta-analysis of experimental studies found that safety training meaningfully increased individual safety knowledge (as well as safe behavior), particularly when training was administered using more engaging methods (e.g., experiential learning). Burke et al. also revealed that safety training tends to have a greater impact on safety-related knowledge attainment when work conditions are more hazardous due to the greater salience of personal safety under more dangerous circumstances (Prentice-Dunn & Rogers, 1986).

Linkage 3. In Campbell et al.'s (1993) theory of job performance, personal experiences and history are also posited to affect individual knowledge, skills, and motivation. Similarly, Burke and Signal (2010) theorized that experiencing safety incidents such as accidents or illnesses correspondingly influences individual safety knowledge and motivation via dialogue and reflection. That is, those individuals who experience safety incidents and who reflect upon them should learn more effectively how to mitigate future incidents and likewise be more motivated to prevent such incidents from recurring. Consistent with this expectation, Morris and Moore (2000) found in a sample of licensed pilots that experiencing near accidents produced counterfactual thinking (thoughts of what "might have been") that promoted learning among the pilots regarding how to avoid future close calls. The authors discovered that the type of counterfactual thinking meaningfully affected pilots' level of learning. Specifically, imagining how the outcome could have been better (as opposed to worse) and focusing inwardly for the solution (as opposed to outwardly) increased learning. These findings were replicated in follow-up laboratory simulations, providing support for the notion that reflecting on safety incidents can facilitate the development of safety-related knowledge.

Although we identified few studies that explicitly examined this linkage (cf. Eklöf & Törner, 2005), others have tested it, though perhaps incidentally.[1] Given the common practice in the safety literature of using retrospective accident reports as a dependent variable (Beus et al., 2010), we identified a handful of studies that correlated past accidents and injuries with both safety knowledge and safety motivation (e.g., Probst, 2004; Vinodkumar & Bhasi, 2010; Zacharatos, Barling, & Iverson, 2005). In fact, Christian et al. (2009) reported corrected meta-analytic correlations between a retrospective accident and injury composite and both safety knowledge ($\rho = -.11$, $k = 3$, 95% CI [−.33, .12]) and safety motivation ($\rho = -.20$, $k = 2$, 95% CI [−.29, −.11]), indicating that both relationships are small to moderate in magnitude. We note, however, that the meta-analyzed associations between safety knowledge and safety incidents involved generic safety knowledge (as opposed to specific lessons learned from a particular accident) and as such probably do not reflect the true magnitude of this relationship. We thus encourage future research to further investigate this linkage, considering both safety knowledge and motivation as outcomes of safety incidents and identifying relevant boundary conditions for these relationships.

Linkage 4. As the mediating mechanisms in this causal sequence, safety knowledge, skills, and motivation represent the core proximal determinants of individual safety-related behavior based on job performance theory (Campbell

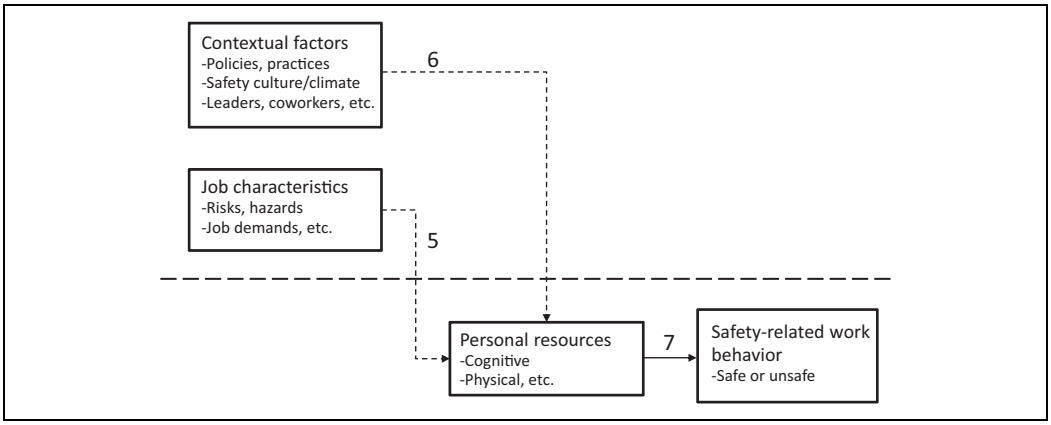

Figure 3. Causal sequence explained by the job demands-resources model.
Dotted arrows represent cross-level relationships.

et al., 1993; Neal & Griffin, 2004). In support of this linkage, Christian et al. (2009) reported strong, positive meta-analytic associations between both safety knowledge ($\rho = .61$, $k = 9$, 95% CI [.50, .72]) and motivation ($\rho = .57$, $k = 5$, 95% CI [.36, .78]) with individual safety-related behavior. Of the few studies that have explicitly considered safety skill as an antecedent of safety-related behavior (e.g., Eklöf & Törner, 2002), positive relationships have likewise been reported. Considered jointly with the preceding linkages, the workplace safety literature thus generally supports this causal sequence derived from job performance theory.

Future directions. We recommend a number of future research directions pertaining to the linkages in this causal sequence. First, exploring the interactive effects among both individual and contextual factors in predicting safety knowledge, skills, and motivation is important for identifying relevant boundary conditions for the posited linkages. For example, to what extent are the negative effects of some personality characteristics (e.g., fatalism, risk-taking) on safety motivation attenuated by positive safety climates or transformational safety leadership? Second, we recommend testing the relative importance of safety knowledge, skills, and motivation, respectively, in predicting safety-related behaviors; whereas knowledge and skill represent "can do" performance antecedents, safety motivation represents a "will do" behavioral determinant that may be more impactful in predicting safety performance. Further, examining whether differential relationships exist based on the type of behavior considered (e.g., compliance vs. participation, safe vs. unsafe) is also important in furthering knowledge of this causal sequence. For instance, does safety motivation have a stronger impact on more discretionary safety-related behaviors (i.e., participation) relative to rule-prescribed safety behaviors (i.e., compliance)? Tests of questions such as this are needed to further our understanding of the theorized linkages in this causal sequence.

Causal sequence explained by the job demands-resources model

The job demands-resources model (JD-R; Bakker & Demerouti, 2007; Demerouti et al., 2001) forms the basis for a second causal sequence embedded within the ISM. This causal sequence is depicted in Figure 3. The JD-R

applied to safety posits that safety-related job demands (e.g., work overload, job risks/hazards) and job resources (e.g., social support, autonomy) influence individuals' safety-related behaviors through their effects on the availability of personal resources (Nahrgang et al., 2011). Personal resources are defined broadly as factors that facilitate personal goal attainment (Halbesleben, Neveu, Paustian-Underdahl, & Westman, 2014). However, given the intentionally expansive nature of this definition, we refine our conceptualization of personal resources for this review to constitute factors that reflect an individual's level of personal energy or capacity to accomplish work (see also "energy resources" as discussed by Zohar, Tzischinski, & Epstein, 2003). We use this narrower definition to be consistent with existing safety-related research on the subject and to better differentiate personal resources from other constructs in the ISM that also facilitate goal attainment (e.g., safety knowledge, skills, and motivation). Correspondingly, indicators of the *absence* of personal resources that have been assessed in the safety literature include job strain (Hansez & Chmiel, 2010; Leung, Chan, & Yu, 2012), cognitive failure (Wallace & Chen, 2005), exhaustion (Halbesleben, 2010; Seo, Lee, Kim, & Jee, 2015), sleep quality (Hahn & Murphy, 2008; Smith, Totterdell, & Folkard, 1995), and burnout (Nahrgang et al., 2011), whereas indicators of the *presence* of personal resources include psychological empowerment (Ford & Tetrick, 2011), physical work capacity (Lusa, Häkkänen, Luukkonen, & Viikari-Juntura, 2002) and engagement (Nahrgang et al., 2011).

According to the JD-R, whereas job demands deplete the availability of personal resources, job resources can both replenish personal resources and lessen the negative effects of job demands, thereby improving goal attainment (Bakker & Demerouti, 2007). This model has been tested multiple times in the workplace safety literature to explain how the availability of personal resources is associated with safety-related behavior (e.g., Dai, Milkman, Hofmann, & Staats, 2015; Li, Jiang, Yao, & Li, 2013; Nahrgang et al., 2011). We summarize research on this causal sequence next, giving particular emphasis to Nahrgang et al.'s meta-analytic findings.

Linkage 5. Linkage 5 theorizes a direct relationship between safety-related job characteristics—in the form of either job demands or resources—and the availability of personal resources that should facilitate or hinder safe work behavior (Nahrgang et al., 2011). Job demands and resources are job characteristics that deplete and replenish personal resources, respectively. Examples of safety-related job characteristics representing *job demands* include job risk, work overload, or task complexity (e.g., Ford & Tetrick, 2011; Parker, Axtell, & Turner, 2001) whereas job characteristics constituting *job resources* include autonomy, task variety, or job involvement (e.g., Barling, Kelloway, & Iverson, 2003; Morrow & Crum, 1998). Though job characteristics, like social and organizational factors, technically exist at the group level, they are most often assessed via individuals' perceptions. For example, although a specific job carries with it a risk level that is roughly the same for all individuals who hold the job, this has generally been assessed via individuals' perceptions of job risk (e.g., Leiter & Robichaud, 1997; McLain, 1995) as opposed to using more objective job-level risk indicators (cf. Ford & Tetrick, 2011).

In their meta-analysis, Nahrgang et al. (2011) estimated population relationships between safety-related job demands and resources and the presence (i.e., engagement) and absence of personal resources (i.e., burnout). With regard to job characteristics, Nahrgang et al. reported that autonomy (a job resource) was negatively associated with burnout ($\rho = -.39$, $k = 5$, 95% CI [$-.44$, $-.35$]) and positively associated with engagement ($\rho = .30$, $k = 5$, 95% CI [.13, .48]).

Conversely, the job demands of perceived risks and hazards and task complexity were positively associated with burnout (perceived risks and hazards, $\rho = .28$, $k = 8$, 95% CI [.18, .39]; task complexity, $\rho = .24$, $k = 5$, 95% CI [.03, .44]) and negatively associated with engagement (perceived risks and hazards, $\rho = -.67$, $k = 18$, 95% CI [−.76, −.59]; task complexity, $\rho = -.52$, $k = 6$, 95% CI [−.71, −.33]). However, physical job demands were not meaningfully related to either burnout ($\rho = .01$, $k = 11$, 95% CI [−.22, .24]) or engagement ($\rho = -.28$, $k = 21$, 95% CI [−.49, .08]). Relative weight analyses of these job demands indicated that perceived risks and hazards accounted for more than half of the explained variance in both burnout (57%; $R^2 = .07$) and engagement (61%; $R^2 = .37$) relative to task complexity (burnout, 39%, $R^2 = .05$; engagement, 34%, $R^2 = .21$) and physical job demands (burnout, 4%, $R^2 = .01$; engagement, 5%, $R^2 = .03$), underscoring the particular importance of perceived job risk in affecting the availability of personal resources. In sum, these meta-analytic findings generally support Linkage 5, suggesting that safety-related job resources and demands respectively are associated with both the presence and absence of personal resources.

Linkage 6. In addition to meta-analyzing job characteristics as antecedents of personal resources, Nahrgang et al. (2011) also meta-analytically estimated contextual factors as individual-level antecedents. While results indicated that social support, safety leadership, and individual safety climate perceptions (context-related job resources) were negatively associated with burnout, they were each positively associated with engagement. In combination with autonomy and individual job knowledge, these context-related job resources collectively accounted for 23% of the variance in burnout and 67% of the variance in engagement. Excluding the job characteristic of autonomy which accounted for the largest proportion of explained variance in burnout (37%, $R^2 = .09$), safety leadership was the next most impactful predictor (25%, $R^2 = .06$), followed by individual safety climate perceptions (23%, $R^2 = .05$). For engagement, safety climate perceptions accounted for the largest proportion of explained variance (42%, $R^2 = .28$) relative to the other job resources. Clarke (2010) likewise reported positive meta-analytic associations between safety climate perceptions and personal resources (e.g., physical well-being).

Taken together, these meta-analytic findings support the expectation that safety-related contextual factors are associated with the presence of personal resources. However, we note that in addition to being conducted solely at the individual level, the majority of studies included in these meta-analyses used cross-sectional designs and solely self-reported data; thus, their population estimates may be somewhat liberal based on the potential influence of common method bias (Sharma, Yetton, & Crawford, 2009). Future tests of this linkage can mitigate concerns of common method bias to a greater degree by obtaining both self and other-reported data or by utilizing time-lagged research designs (cf. Halbesleben et al., 2013).

Linkage 7. The availability of personal resources is posited to transmit the effects of safety-related job demands and job resources (whether job characteristics or contextual factors) on individuals' safety-related behaviors (Nahrgang et al., 2011). Consistent with the JD-R, Nahrgang et al. reported a moderate, negative association between engagement (the presence of personal resources) and unsafe behavior ($\rho = -.28$, $k = 20$, 95% CI [−.41, −.15]) and a moderate, positive association between burnout (the absence of personal resources) and unsafe behavior ($\rho = .32$, $k = 3$, 95% CI [−.12, .76]). In combination with the supporting evidence for Linkages 5 and 6, these findings support the causal sequence posited by the JD-R when applied to the domain of safety. However, it is noteworthy that Nahrgang et al.

found evidence of partial mediation suggesting that job demands and resources are also directly related to both safety-related behaviors and safety incidents in addition to their indirect effect through personal resources.

Future directions. Although the JD-R posits that the presence of job resources should attenuate the negative effects of job demands on personal resources—in addition to directly increasing personal resources (Bakker & Demerouti, 2007)—we found no safety research that directly tested this moderating effect. However, in an indirect test of this expected interaction, Turner, Chmiel, Hershcovis, and Walls (2010) found that the negative association between role overload (a job demand) and experiencing hazardous work events was attenuated by perceived coworker support (a job resource), though not by perceived managerial or supervisory support. In this case, although personal resources were not assessed, we infer their presence/absence to be subsumed by the more distal associations between job demands/resources and experiencing hazards. Similarly, in a longitudinal study of health care providers, Dai et al. (2015) discovered that different job demands can interact with each other to negatively impact safety compliance. Specifically, the authors found that longer periods of time at work and greater work intensity (both job demands) combined to more quickly reduce compliance with safety procedures, presumably via the depletion of personal resources. Taken together, although these studies indirectly support the theoretical expectation that job demands and resources interact with each other in affecting the availability of personal resources, there remains a need in the safety literature to directly assess the presence of personal resources when testing this expectation. For example, research could examine the extent to which contextual job resources such as coworker support for safety or a favorable safety climate attenuate the adverse effects of perceived job risk on individual burnout or engagement. We also recommend that researchers explore other boundary conditions in this causal sequence. One identified by Ford and Tetrick (2011) regarding Linkage 7 indicates that the positive relationships between personal resources (i.e., psychological empowerment, organizational identification) and safe behavior (i.e., use of personal protective equipment) are strengthened by perceived supervisor safety practices.

Because this causal sequence has largely been tested using correlational study designs, we encourage designs that provide greater ability to infer causation. For example, tests of Linkage 5 could be strengthened by experimentally manipulating job characteristics as was done with job insecurity in an experiment conducted by Probst (2002). In addition, assessing job characteristics and contextual factors at group levels and analyzing them as cross-level predictors of personal resources (cf. Ford & Tetrick, 2011) would likewise bolster empirical findings because the independent variables would be assessed at the appropriate theoretical level of analysis. In summary, despite a growing body of empirical support for this causal sequence, we recommend that future research increase understanding by testing moderators such as those mentioned before and by using study designs that strengthen our ability to make causal inferences.

Causal sequence explained by organizational climate theory

According to organizational climate theory, behavior-outcome expectancy mediates the influence of contextual factors on both individual safety-related behavior as well as group-level patterns of safety-related behavior (Zohar, 2011; Zohar & Hofmann, 2012). Behavior-outcome expectancy represents employees' motivational expectation regarding whether (or to what degree) certain behaviors will be reinforced in their organizational setting (Zohar, 2011). These perceptions may be based upon

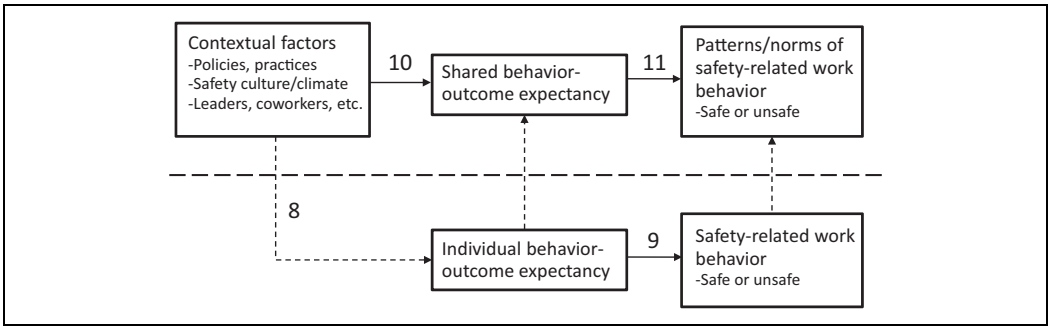

Figure 4. Causal sequence explained by organizational climate theory.
Dotted arrows represent cross-level relationships; nonnumbered dotted arrows are used to indicate aggregate or emergent processes between individual-level constructs and their group-level manifestations.

the expectation of organizational rewards—whether formal or informal—or the expectation of personal safety as both outcomes are inherently reinforcing. Though behavior-outcome expectancy can be considered to be a form of motivation, it remains distinct from Griffin and Neal's (2000) conceptualization of safety motivation. When considered under the lens of expectancy theory (Vroom, 1964), Griffin and Neal's (2000) description of safety motivation is predominantly a function of valence (i.e., motivation based on the perceived value of safety), whereas Zohar's (2011) conceptualization of behavior-outcome expectancy is a product of instrumentality (i.e., motivation based on the perceived connection between behaviors and desired outcomes). Thus, although both constructs can accurately be described as motivation, they are the products of differing core cognitions (i.e., valence vs. instrumentality) and are thus treated separately in the ISM.

Behavior-outcome expectancy is an important context-based driver of individual and group-level behavior because people are naturally motivated to identify cues in their environment that communicate the behaviors that will be most advantageous in terms of bringing about desired outcomes (Schneider, 1975). Although theory concerning this causal sequence has focused on safety climate as the chief source of safety-related behavior-outcome expectancies (Zohar, 2011)—given that safety climate is a perceptual indication of the social context of safety—existing empirical support predominantly involves narrower contextual factors which can generally be conceptualized as indicators of climate. This causal sequence based on climate theory is displayed in Figure 4.

Linkages 8, 9, 10, and 11. Because the few studies that have examined these linkages have tended to consider the entire causal sequence—though often indirectly—we review the four linkages simultaneously for ease of presentation. Whereas Linkages 8 and 9 concern the contextual factors→behavior-outcome expectancy→safety-related behavior sequence of relationships at the individual level of analysis, Linkages 10 and 11 reflect this sequence of relationships at the group level of analysis.

Our search identified no empirical tests of Linkages 8 and 9 in the selected journals between 1980 and 2015. However, an older study experimentally manipulated these relationships (Rubinsky & Smith, 1973) and we review it here in the absence of more recent individual-level tests. In a series of laboratory experiments conducted at the individual level of analysis, Rubinsky and Smith (1973) used training to establish a behavior-outcome expectancy and ultimately change safety-related behavior. Specifically, when participants failed

to follow safety protocol, the experimenters simulated the occurrence of accidents. Doing so created a behavior-outcome expectancy among the participants (i.e., failing to follow safety protocol causes "accidents") which led to safer behavior—and thus fewer "accidents"—in subsequent test sessions. In this case, the training and subsequent accident simulations informed participants of the consequences of unsafe behavior which in turn altered safety-related behavior.

At the group level of analysis, Zohar (2002) demonstrated in a quasi-experimental field study that providing targeted feedback to supervisors increased their safety-related interactions with subordinates and subsequently improved group-level safe behavior (i.e., rate of ear plug use) over time. These repeated supervisor interactions communicated to workers a higher priority of safety and thus better outcomes for working safely. Recent experimental field studies by Zohar and Polachek (2014) and Naveh and Katz-Navon (2015) revealed comparable effects based on supervisor feedback and climate-focused organizational interventions, respectively. Likewise, an older study (Komaki, Barwick, & Scott, 1978)—published prior to 1980 but discussed here for completeness—found that the combination of safety training followed by feedback provided directly to subordinates (in the form of positive reinforcement for safe behavior) noticeably increased observations of group safe behavior over a period of 25 weeks in comparison to a control group that revealed no such changes. In each of these cases, unambiguous work circumstances (e.g., targeted safety-related feedback) likely caused individual behavior-outcome expectancies to become shared through mutual experience (Schneider & Reichers, 1983) and thus emerge as a group-level construct that subsequently altered group patterns and norms of safety-related behavior.

Taken together, these studies suggest that behavior-outcome expectancies can be altered at the individual and group levels by contextual factors such as safety training, safety-related feedback, and policy changes and that altered behavior-outcome expectancies in turn affect subsequent safety-related behaviors. We note, however, that none of the aforementioned studies directly assessed behavior-outcome expectancy. Rather, they created situations in which information was provided to individuals or groups either in the form of training or feedback that communicated the outcomes associated with working safely (or unsafely).

Similarly, although climate theory posits that contextual factors affect safety-related behavior through behavior-outcome expectancy, a large body of research has examined direct, unmediated associations between contextual factors and safety-related behaviors that theoretically subsume behavior-outcome expectancy. Of the contextual factors that have been directly linked with safety-related behavior, none has been tested more frequently than safety climate. Safety climate represents employees' shared perceptions regarding the priority of safety (Zohar, 2011). Christian et al. (2009) meta-analyzed the direct relationship between safety climate and safety-related behavior, revealing moderate, positive relationships at both the individual ($\rho = .49$, $k = 31$, 95% CI [.40, .58]) and group levels ($\rho = .51$, $k = 10$, 95% CI [.36, .66]). Nahrgang et al. (2011) and Clarke (2006) also meta-analyzed this relationship at the individual level of analysis and reported comparable effect sizes. Additional contextual factors that have been examined as direct correlates of safety-related behavior (though predominantly at the individual level) include transformational leadership (Inness, Turner, Barling, & Stride, 2010), coworker safety norms (Watson, Scott, Bishop, & Turnbeaugh, 2005), and organization-initiated goal setting and feedback (Cooper, Phillips, Sutherland, & Makin, 1994).

Future directions. Because behavior-outcome expectancy was not directly assessed in the previously cited studies, we cannot be certain

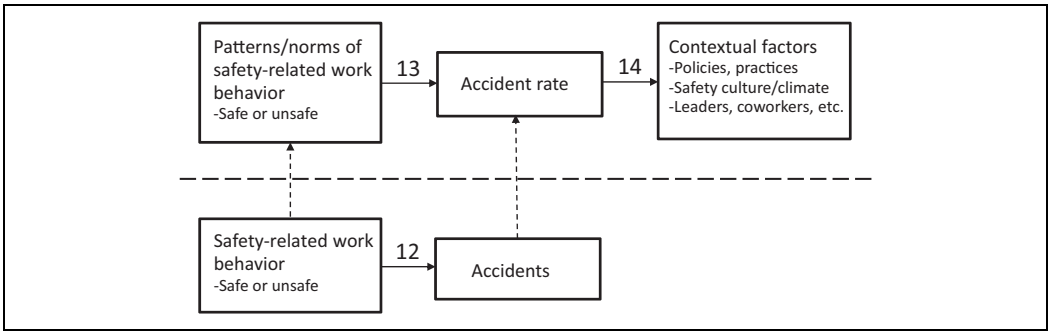

Figure 5. Causal sequence including accidents.
Nonnumbered dotted arrows are used to indicate aggregate or emergent processes between individual-level constructs and their group-level manifestations.

that instrumental perceptions of the extent to which reinforcement is tied to safety-related behavior acts as the mediating mechanism in the associations between contextual factors and safety-related behavior. We thus encourage future studies that directly measure behavior-outcome expectancy and also studies which manipulate these motivational expectancies using relevant contextual factors to substantiate this proposed mediating mechanism. Additionally, although evidence suggests that organizational practices that positively reinforce safe behavior can alter safety-related behaviors for an extended period of time, these effects can dissipate quickly when positive reinforcement is stopped (Komaki et al., 1978). Further research is needed which takes a temporal perspective regarding the length of time organizational practices such as this can remain efficacious in altering behavior-outcome expectancies and subsequent behavior and to understand the competing factors (e.g., productivity demands) that can impede such efforts.

Causal sequence involving accidents

In the preceding causal sequences (Figures 2–4), we focused on safety-related behavior as the core dependent variable—whether considered at the individual or group levels—because safety-related behaviors can indicate both the presence and absence of safety and because of the proximal influence that behaviors have on the occurrence of workplace accidents. Accidents, in turn, have been theorized and investigated as antecedents of contextual factors (e.g., safety climate, organizational policies) because of their damaging and disruptive nature as well as their ability to impact organizational learning. Though not guided by a particular theoretical framework like the preceding causal sequences, we next review research that has examined the relationships between safety-related behavior, accidents, and subsequent contextual factors to show the natural feedback loop that exists in the domain of workplace safety. See Figure 5 for an illustration of these relationships.

Linkages 12 and 13. At the individual level of analysis, population estimates of the relationship between safety-related behavior and accidents (Linkage 12)—whether behavior was operationalized as compliance, participation, unsafe behavior, or a composite—have been reported by at least six different meta-analyses (i.e., Beus et al., 2015; Christian et al., 2009; Clarke, 2006, 2010, 2012; Nahrgang et al., 2011) with effect size estimates ranging from $-.09$ ($k = 9$; Clarke, 2006) to $-.31$ ($k = 6$;

Christian et al., 2009). Of these meta-analyses, Nahrgang et al. is arguably the most informative based on the number of samples that contributed to their population estimates and the separate consideration of safety compliance, participation/engagement, and unsafe behavior. These authors reported comparable associations between safety-related behavior and accidents for safety compliance ($\rho = -.20$, $k = 24$, 95% CI [−.27, −.12]) and unsafe behavior ($\rho = .24$, $k = 16$, 95% CI [.11, .37]), and a weaker, nonstatistically significant association between safety participation/engagement and accidents ($\rho = -.08$, $k = 13$, 95% CI [−.18, .02]). With the exception of safety participation behaviors, these meta-analytic estimates support the natural expectation that safer workplace behaviors are associated (albeit relatively weakly) with fewer accident occurrences.

At the group level of analysis, far fewer studies have examined the link between group-level patterns of safety-related behavior and accident rates (Linkage 13). However, the research that has been done generally mirrors findings from the individual level of analysis indicating that safety-related behaviors are weakly, negatively associated with accidents. For example, Neal and Griffin (2006) reported one-year-lagged group-level correlations between safe behavior and subsequent accidents of −.15 and −.19 in a healthcare setting. Similarly, in a manufacturing sample, Cooper et al. (1994) reported a group-level association of −.20 between safety performance and accident rate. A stronger, though moderate, positive association ($r = .35$) was reported by Hechanova-Alampay and Beehr (2001) between *unsafe* behaviors and accidents. The somewhat stronger magnitude of this relationship is perhaps a result of more appropriately aligning the examined behaviors with the outcome of interest given that both unsafe behaviors and accidents reflect a lack of safety.

Taken together, empirical examinations of these linkages suggest that individual and group-level safety-related behaviors are weakly to moderately associated with accident occurrences. We believe the relatively small magnitude of these associations is noteworthy for a combination of reasons. First, it underscores that much of what precipitates workplace accidents is influenced by factors outside of, or that must coincide with, employee behavior (e.g., organizational decisions, environmental characteristics; Reason, 1990). Second, despite the fact that accidents are multiply determined, the small magnitude of behavior–accident effect sizes may simultaneously indicate that current measures of safety-related behavior are deficient. We expand on this in the Future Directions section that follows.

Linkage 14. Although accidents are by definition detrimental to organizations and can weaken employee perceptions of the priority of safety (Bergman, Payne, Taylor, & Beus, 2014; Beus et al., 2010), they can also serve as learning events that influence subsequent policy and mitigate future accident occurrences (e.g., Madsen, 2009). With regard to the detrimental downstream effects of accidents, Beus et al. (2010) meta-analytically distinguished between safety climate–injury associations based on whether injuries occurred before or after safety climate assessment. In cases where the injuries occurred prior to assessing safety climate—such that injuries could be conceptualized as antecedents of safety climate perceptions—Beus et al. reported small to moderate, negative associations at both the individual ($\rho = -.16$, $k = 32$, 95% CI [−.19, −.11]) and group levels ($\rho = -.29$, $k = 10$, 95% CI [−.41, −.10]). This suggests that workplace injuries are associated with more negative subsequent safety climate perceptions. Beus et al. also found that these relationships tended to be stronger when injuries were restricted to those that resulted in more than basic first aid treatment. Thus, not surprisingly, severe injuries appear to have more detrimental effects on safety climate perceptions than predominantly less severe injuries.

Additional research, conducted primarily at the organization level, has conceptualized accidents as events that can facilitate organization learning. For example, Madsen (2009) reported that coal mines which experienced fatal accidents tended to have fewer subsequent occurrences of fatalities, presumably as a result of organizational learning. Similar effects have been reported with airlines (Haunschild & Sullivan, 2002), nuclear power plants (Marcus, 1988), and railroads (Baum & Dahlin, 2007). Overall, it appears that organizations do learn from the occurrence of accidents (i.e. that future accident rates decrease). However, various factors appear to impact the level of learning following accidents. For example, organizations may learn more when the cause of an accident is more complex or heterogeneous (Haunschild & Sullivan, 2002), when the accident is more severe (Madsen, 2009), and when organizations respond to accidents more autonomously (e.g., choosing to go beyond external regulations) as opposed to solely complying with the letter of externally imposed regulations (Marcus, 1988). Also, research indicates that deviation from accident rate aspirations or goals can impact which sources of information are most beneficial for organizations. Specifically, Baum and Dahlin (2007) found that railroads whose performance was below their own goal levels benefited more from other railroads' accident experiences whereas railroads that performed at their goal levels benefited the most in learning from their own accident experiences.

Future directions. Though the organization-level research cited to support Linkage 14 suggests that accidents can facilitate organizational learning, we note that actual organizational learning was not directly assessed in any of these studies. Rather, learning was implied by subsequent reductions in accidents. Thus, future research is needed to assess organizational learning—perhaps in the form of policy changes or the decision to adopt new regulations following accident investigations—to more clearly examine how and to what degree organizations learn from and change following the occurrence of accidents.

As noted regarding Linkages 12 and 13, individual and group-level associations between safety-related behavior and accidents are generally small in magnitude. Although this reflects the fact that accidents are multiply determined (Reason, 1990) and imperfectly reported (Probst, 2015; Probst, Brubaker, & Barsotti, 2008), it may also highlight inadequacies in the assessment of safety-related behavior. For example, whereas a number of generalized measures of safety-related behavior (safe behavior specifically) have been developed and are widely used (e.g., Burke, Sarpy, Tesluk, & Smith-Crowe, 2002; Griffin & Neal, 2000), it is likely that they do not capture the full range of context-specific safety-related behaviors that affect accidents across jobs. Thus, although such measures may be useful for purposes of generalization, context-specific safety-related behavior measures may be needed to more accurately estimate the link between safety-related behavior and workplace accidents. Alternatively, the human factors literature has developed more nuanced conceptualizations of safety-related behaviors that could be useful in establishing greater specificity in future workplace assessments (e.g., Rasmussen, 1983; Reason, 1990; Wiegmann & Shappell, 2003).

In addition to the possible influence of content deficiency in safety-related behavior measures, a specific limitation of reported associations between safety-related behavior and accidents across levels of analysis is that the examined accidents most often occurred *prior* to assessing behavior. This presumes that accident occurrences do not influence subsequent behavior which may be an untenable assumption. We encourage the examination of time-lagged associations that allow for accident data to be gathered following the assessment of safety-related behavior (cf. Halbesleben, 2010; Neal & Griffin, 2006) as this should provide a

stronger basis regarding the directionality of this relationship. Also, because of the likelihood of socially desirable responding when reporting one's own safety-related behavior, we recommend using non-self-report measures where possible such as supervisor reports (e.g., Hofmann, Morgeson, & Gerras, 2003; Wallace & Chen, 2006), unobtrusive behavioral observation (e.g., Komaki et al., 1978; Zohar, 2002), or independently conducted safety audits (e.g., Zohar & Polachek, 2014) to assess either individual or group-level safety-related behavior. In summary, although the link between safety-related behavior and accidents may not be strong in reality given the multitude of factors that contribute to accident occurrences (Reason, 1990), it is probable that current empirical estimates are attenuated because of the noted measurement problems. We next synthesize the findings of this review and advance an agenda for future research based on our conclusions.

Discussion

The purpose of this integrative review was to (a) summarize what the field of workplace safety has accomplished and (b) articulate what the field has yet to accomplish and thereby provide a path forward for future research to follow. As a precursor to addressing these objectives, we provided needed clarity to the field by formally defining workplace safety as an attribute of work systems that reflects the (low) likelihood of physical harm to persons, property, or the environment during the performance of work. However, to be consistent with the literature that formed the basis of our review, we limited our working definition of safety to apply to the likelihood of physical harm to persons only. We then used this working definition to draw important conceptual distinctions between the most widely used indicators of workplace safety (i.e., safety-related behaviors and accidents).

To achieve this review's first objective (i.e., to summarize current workplace safety research), we combined several existing conceptual models of workplace safety—representing causal sequences with different theoretical bases—into the ISM (see Figure 1). This was done to form an overarching representation of current theoretical expectations concerning workplace safety. We then used the ISM as the basis for reviewing the safety literature to determine how well evidence supports current theoretical expectations. Although some linkages in the model have received stronger empirical substantiation than others, the extant literature appears to provide incomplete support for the ISM as a whole, particularly at group levels of analysis. Figure 2 depicts the degree to which we judged empirical evidence to support each of the 14 theoretical linkages in the ISM. Based on a careful review of the studies gleaned from search results, we qualitatively evaluated each theoretical linkage as having either substantive, moderate, or weak empirical support.

We judged linkages with *substantive support* to be those for which additional tests of the basic linkage would not be particularly value-adding to the literature. In these cases, any remaining empirical tests should be aimed at identifying unknown boundary conditions (i.e., moderators). For linkages judged to have *moderate support*, although the basic theoretical linkage may have been supported by multiple studies, these are linkages that we believe still require additional tests and/or more rigorous empirical designs to substantiate theoretical expectations. Finally, we judged linkages with *weak support* to be those that still require even basic empirical tests to support theoretical expectations.

As can be seen from Figure 6, we judged seven linkages (50%) to have weak or insufficient empirical support based on the studies located in our search. Whereas Linkages 8, 9, 10, and 11 still require the direct assessment of behavior-outcome expectancy to better support theoretical expectations, Linkage 1 necessitates consideration of a broader set of individual

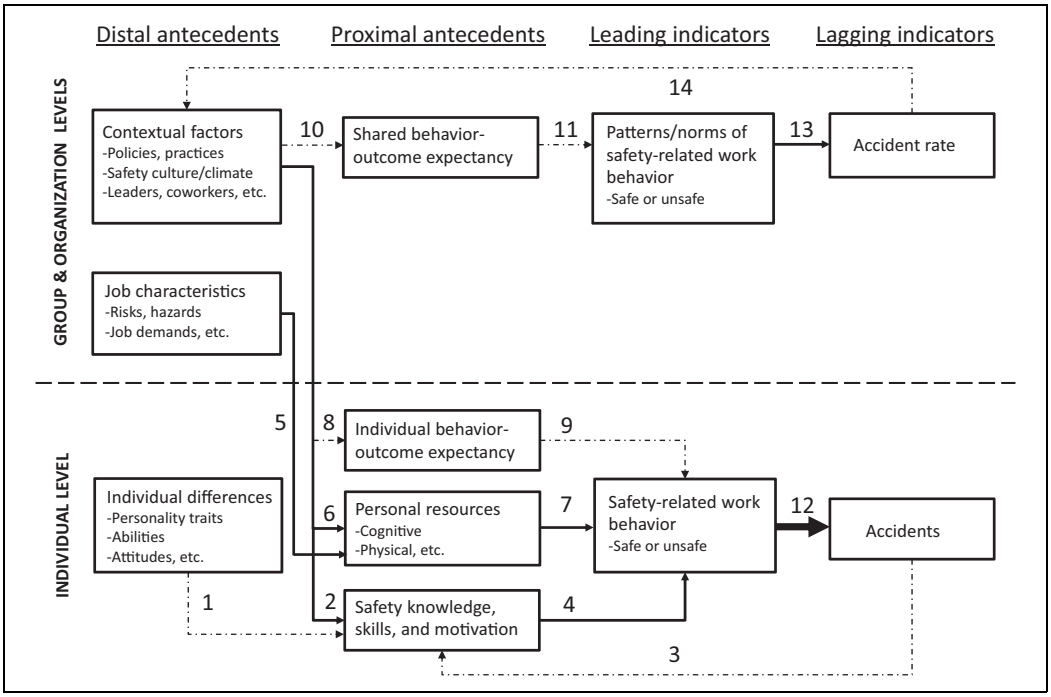

Figure 6. Empirical support for the integrated safety model.
The thickest lines indicate substantive empirical support (i.e., Link 12); the middle-sized lines indicate moderate empirical support (i.e., Links 2, 4, 5, 6, 7, 13); the dashed lines indicate weak or insufficient empirical support (i.e., Links 1, 3, 8, 9, 10, 11, 14). Note that the thickness of arrows is not an indication of effect size but rather the extent and clarity of empirical findings regarding the linkage.

differences as well as more frequent assessment of both safety knowledge and skills as dependent variables. Linkages 3 and 14 suffer similarly from a lack of breadth in the examination of individual and context-related dependent variables that have been connected with past accident occurrences. Consequently, even basic correlational assessments of these theoretical relationships could advance current understanding.

We judged six (43%) of the linkages to have moderate empirical support. For example, although empirical relationships have been established for Linkages 5 and 6 (i.e., job characteristics and contextual factors to personal resources; Nahrgang et al., 2011), these relationships have been supported predominantly using cross-sectional, single-source study designs (cf. Chowdhury & Endres, 2010). The same is largely true of Linkages 2, 4, 7, and 13. We thus encourage more rigorous empirical examinations to substantiate these relationships. Conducting cross-level, multisource variable assessments where applicable and using time-lagged and/or experimental study designs would be particularly value-adding.

We deemed only one of the 14 linkages (7%) to have substantive empirical support (i.e., Linkage 12), though we reiterate that this should not preclude research efforts aimed at identifying unknown boundary conditions in this relationship. Rather, we believe there is little added value in examining the basic individual-level relationship between safety-related work behavior and accidents given that

it is well-established meta-analytically that this relationship is small to moderate in magnitude (e.g., Beus et al., 2015; Christian et al., 2009; Nahrgang et al., 2011). Instead, any additional examination of this linkage should consider the previously noted measurement issues and explore factors such as job design (e.g., mechanistic vs. autonomous jobs) or organizational safeguards (whether procedural or structural) that may either attenuate or accentuate the connection between safety-related behaviors and workplace accidents.

Taken together, although we believe that the existing research base has contributed meaningfully to both safety research and practice, these summary findings suggest there is much yet to be done to empirically substantiate current theoretical expectations. This underscores the importance of the second general objective of this review which is to illuminate a path forward for workplace safety research. We first addressed this objective, in part, in the main body of this review by discussing specific research needs regarding each of the summarized causal sequences within the ISM. However, to expand upon this objective at a more general level, we next discuss deficiencies of the ISM (i.e., missing links) and then provide recommendations for using more generalized theoretical frameworks to broaden and integrate our understanding of workplace safety.

Missing links

As we noted at the outset of this review, our purpose in forming the ISM was not to promote a new conceptual model or to form a perfect or complete representation of the nomological net for workplace safety. Rather, it was to synthesize current thinking regarding workplace safety in the organizational sciences and provide a theoretical baseline for future research to build upon. Both safety research and theory suggest that there are a number of linkages that could be added to the ISM to more comprehensively capture the mechanisms through which individual and group-level safety-related behaviors are influenced. Though it is not our intent to identify all possible missing linkages here, we highlight a handful in the following lines to draw attention to potential paths for future workplace safety research to follow.

For example, Wallace and Chen's (2005) study using a sample of maintenance employees suggests there is a theoretical link between individual difference variables and the availability of personal resources. The authors found that the five-factor model personality traits of conscientiousness and neuroticism were meaningfully associated with cognitive failure at work (i.e., cognitive lapses in attention, memory, or motor function). Whereas conscientiousness was negatively associated with cognitive failure, perhaps due to an increased tendency to pay attention to detail, neuroticism was positively associated as a possible byproduct of being distracted by anxiety or stress (Wallace & Chen, 2005). This suggests that personality traits can meaningfully affect the availability of personal resources and represents an additional mediating mechanism through which individual differences may affect safety-related behaviors.

The occurrence of injuries has likewise been identified as a direct antecedent of personal resources, representing another missing link in the ISM. Specifically, Halbesleben (2010) found that the self-reported frequency and severity of injuries were significantly, positively associated with subsequent employee exhaustion, an indicator of depleted personal resources. Though workplace injuries or accidents are most often examined as outcome variables, we believe there is merit in considering additional theoretical links between accidents and personal or organizational factors in which accidents are conceptualized as predictor variables (see Leiter, Zanaletti, & Argentero, 2009; Stride et al., 2013), due to the impactful nature of such events for both individuals and organizations.

In addition to limited consideration of accidents as predictor variables, it is noteworthy how few mediating mechanisms have been proposed at group levels to represent proximal antecedents of group patterns of safety-related behavior. We posit that the proximal antecedents that have been tested at the individual level (e.g., personal resources, safety knowledge, or safety skills) may likewise represent important mediating mechanisms at group levels. Whereas personal resources (e.g., psychological empowerment, engagement) are factors that indicate an individual's capacity to accomplish work when considered at the individual level (Halbesleben et al., 2014), team or organizational resources can correspondingly be considered factors that reflect a *group's* capacity to accomplish work. Team or organizational resources with safety-related implications include variables such as team cohesion or shared mental models (e.g., Smith-Jentsch, Mathieu, & Kraiger, 2005) given that higher levels of either of these factors can reflect a greater capacity for a group to achieve safety-related objectives (Marks, Mathieu, & Zaccaro, 2001; Mohammed, Ferzandi, & Hamilton, 2010). The presence of team-level resources such as these could serve as a mediating mechanism through which job characteristics or contextual factors affect group-level patterns of safety-related behaviors (Turner & Parker, 2004). For example, a favorable safety climate that places a high priority on workplace safety should establish greater similarity and accuracy in team mental models regarding safety which should in turn lead to more effective group patterns of safety-related behavior.

In addition to the "missing links" just highlighted, we invite researchers to critically evaluate the ISM and consider other theoretically relevant linkages that can be used to enhance the model's comprehensiveness. We believe careful consideration of additional conceptual linkages will provide meaningful improvements to the ISM and advance our understanding of the factors that affect workplace safety.

Expanding workplace safety theory

Of the prominent theories that have been used to explain workplace safety, and which formed the basis for the ISM, it is noteworthy that none are particularly well-equipped to explain within-person or within-group variation in safety-related behavior. Rather, job performance theory, the JD-R, and climate theory have each been used predominantly to explain between-person or between-group variation in safety-related behavior. Thus, there is a need to expand workplace safety theory to be able to explain why individuals, groups, and organizations choose to engage (or not) in certain safety-related behaviors or practices at some times and not others. We believe that motivation theories are best equipped to answer this general question and illustrate next how the combination of control theory and expectancy theory represents one means of explaining within-subject variation in safety-related behavior across levels of analysis.

A control theory perspective on workplace safety suggests that individuals and groups will be motivated to adjust safety-related behaviors or practices when there is a discrepancy judged between current and desired safety levels (Carver & Scheier, 1982; Edwards, 1992; Lord, Diefendorff, Schmidt, & Hall, 2010). It is reasonable to expect a perceived safety discrepancy to be troubling—and thus motivating—to individuals and organizations given that safety is both a basic individual need (Higgins, 2000; Maslow, 1943; Pittman & Zeigler, 2007) and a requisite condition to maximize organizational success (Bigley & Roberts, 2001; Hofmann et al., 1995). Thus, if an individual or group perceives that they are less safe than they desire to be, they will be motivated to change their behaviors or practices in an effort to reduce the discrepancy and achieve the desired safety level (Beus, 2012). Conversely, if an individual or group perceives no discrepancy (i.e., their need or desire for safety *is* satisfied), they may either maintain their existing safety-related efforts or

potentially reduce them to increase the efficiency of goal attainment (Lord et al., 2010; Schmidt & DeShon, 2009). Stated simply, control theory explains within-person or within-group variation in safety-related behavior as a function of discrepancy detection or goal evaluation.

Although safety is an inherently compelling individual and group objective (Hofmann et al., 1995; Maslow, 1943), there are other—and often competing—goals that can change the extent to which safety motivates behavior at work. For example, despite the prevalence of organizational slogans such as "safety first," making money is arguably a superordinate goal for both individuals and organizations relative to safety (Lea & Webley, 2006; Locke, Feren, McCaleb, Shaw, & Denny, 1980; Rynes, Gerhart, & Minette, 2004). It is doubtful that individuals choose to work because safety is their primary goal or that organizations come into existence for the express purpose of providing a safe work environment. Thus, a within-subject theory of workplace safety must account for the existence of goals that may at times be more valued or salient than safety as these will undoubtedly influence variation in safety-related behaviors. Expectancy theory (Vroom, 1964) is one such theory that has demonstrated broad explanatory power in the organizational sciences (Diefendorff & Chandler, 2011). As a complement to control theory, which explains how safety discrepancies motivate safety-related behavior (largely independent of other considerations), expectancy theory is able to explain how individual or group behavior is affected by the existence of competing goals (Klein, Austin, & Cooper, 2008).

According to expectancy theory, motivation to pursue a desired outcome or goal (e.g., safety, productivity) is a function of three core cognitive evaluations: (a) valence, or the perceived attractiveness of the outcome; (b) instrumentality, the perceived likelihood that specific behaviors will lead to the desired outcome; and (c) expectancy, the perceived certainty of being able to perform the behaviors that lead to the desired outcome (Vroom, 1964). Higher levels of each of these cognitions are associated with greater motivation to pursue a particular goal or outcome relative to another (van Eerde & Thierry, 1996). Although the goals of safety and productivity are not mutually exclusive, to the extent that productivity may have greater valence, instrumentality, or expectancy for a given individual or organization, it would be expected to exert a stronger impact on behavior relative to safety, particularly under circumstances that limit the breadth of decisions (e.g., time constraints). Conversely, in contexts where the lack of safety may be more severe (e.g., chemical processing industry), safety may have more motivational force relative to productivity or other goals. Thus, expectancy theory, in tandem with control theory, provides a promising means of theorizing when (and to what degree) individuals or organizations may be motivated to work safely or not.

Although these within-subject theoretical perspectives differ from the between-subject theories that form the basis for the ISM, we believe that they offer complementary explanations for workplace safety that can be integrated to further expand safety theory. For example, a contextual factor such as safety climate, which can explain between-group differences in safety-related behavior using climate theory, may likewise affect within-group variation in safety practices. Specifically, for a group with a favorable safety climate, differing work circumstances or competing goals will be less likely to change safety practices from one situation to the next. In contrast, this is less likely to be the case for a group with a less favorable safety climate that may be more swayed by competing goals or objectives. These within and between-subject theories can also be integrated at the individual level of analysis. Whereas varying amounts of personal resources can be used to explain between-person differences in safety-related behavior using the JD-R (Nahrgang et al., 2011), the extent to which these

resources are dedicated to working safely for an individual likely also depends on the degree to which they perceive a discrepancy between their current and desired safety levels as specified by control theory.

In summary, we emphasize the need for workplace safety theory to build upon the ISM by considering theories such as control theory or expectancy theory that can be used to explain within-subject variation in safety-related behavior. We assert that such theories can be used in combination with the more prevalent between-subject theories to enrich current understanding and future research concerning workplace safety.

Conclusion

Workplace safety is of clear individual and organizational importance. This is evidenced by the expanding body of safety-related research that has been published in the organizational sciences, particularly in recent years. However, the breadth of existing research across varied publication outlets necessitated an overarching review and synthesis to both summarize the current state of the field and provide directions for future research. This paper accomplished these objectives by (a) providing a formal definition of workplace safety, (b) creating the ISM to summarize current theoretical expectations, (c) comparing empirical findings against the ISM, and (d) articulating future directions for workplace safety research and providing recommendations to strengthen and extend safety theory. Collectively considered, we believe that these contributions establish greater coherence in the workplace safety literature and in turn direct safety researchers' efforts towards answering the questions that will be the greatest benefit in advancing both the science and practice of workplace safety.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Note

1. We thank the anonymous reviewer who made this observation.

References

Bakker, A. B., & Demerouti, E. (2007). The job demands-resources model: State of the art. *Journal of Managerial Psychology*, *22*, 309–328. doi: 10.1108/02683940710733115

Barling, J., Kelloway, E. K., & Iverson, R. D. (2003). High-quality work, job satisfaction, and occupational injuries. *Journal of Applied Psychology*, *88*, 276–283. doi:10.1037/0021-9010.88.2.276

Barling, J., Loughlin, C., & Kelloway, E. K. (2002). Development and test of a model linking safety-specific transformational leadership and occupational safety. *Journal of Applied Psychology*, *87*, 488–496. doi:10.1037//0021-9010.873.3.488

Baum, J. A., & Dahlin, K. B. (2007). Aspiration performance and railroads' patterns of learning from train wrecks and crashes. *Organization Science*, *18*, 368–385. doi:10.1287/orsc.1060.0239

Bergman, M. E., Payne, S. C., Taylor, A. B., & Beus, J. M. (2014). The shelf life of a safety climate assessment: How long until the relationship with safety-critical incidents expires? *Journal of Business and Psychology*, *29*, 519–540. doi:10.1007/s10869-013-9337-2

Beus, J. M. (2012). *The psychological need for safety at work: A cybernetic perspective*. (Unpublished doctoral dissertation). Texas A&M University, College Station, TX.

Beus, J. M., Dhanani, L. Y., & McCord, M. A. (2015). A meta-analysis of personality and workplace safety: Addressing unanswered questions. *Journal of Applied Psychology*, *100*, 481–498. doi:10.1037/a0037916

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

relationships. *Journal of Applied Psychology*, *95*, 713–727. doi:10.1037/a0019164

Bigley, G. A., & Roberts, K. H. (2001). The incident command system: High-reliability organizing for complex and volatile task environments. *Academy of Management Journal*, *44*, 1281–1299. doi:10.2307/3069401

Bureau of Labor Statistics, U.S. Department of Labor. (2015). *Injuries, illnesses, and fatalities*. Retrieved from http://www.bls.gov/iif/

Burke, M. J., Salvador, R. O., Smith-Crowe, K., Chan-Serafin, S., Smith, A., & Sonesh, S. (2011). The dread factor: How hazards and safety training influence learning and performance. *Journal of Applied Psychology*, *96*, 46–70. doi:10.1037/a0021838

Burke, M. J., Sarpy, S., Tesluk, P. E., & Smith-Crowe, K. (2002). General safety performance: A test of a grounded theoretical model. *Personnel Psychology*, *55*, 429–457. doi:10.1111/j.1744-6570.2002.tb00116.x

Burke, M. J., & Signal, S. M. (2010). Workplace safety: A multilevel, interdisciplinary perspective. In H. Liao, J. J. Martocchio, & A. Joshi (Eds.), *Research in personnel and human resource management* (Vol. 29, pp. 1–47). Retrieved from http://www.emeraldinsight.com/doi/pdfplus/10.1108/S0742-7301%282010%290000029003

Campbell, J. P., McCloy, R. A., Oppler, S. H., & Sager, C. E. (1993). A theory of performance. In N. Schmit & W. C. Borman (Eds.), *Personnel selection in organizations* (pp. 35–70). San Francisco, CA: Jossey-Bass.

Carver, C. S., & Scheier, M. F. (1982). Control theory: A useful conceptual framework for personality-social, clinical, and health psychology. *Psychological Bulletin*, *92*, 111–135. doi:10.1037/0033-2909.92.1.111

Chowdhury, S. K., & Endres, M. L. (2010). The impact of client variability on nurses' occupational strain and injury: Cross-level moderation by safety climate. *Academy of Management Journal*, *53*, 182–198. doi:10.5465/AMJ.2010.48037720

Christian, M. S., Bradley, J. C., Wallace, J. C., & Burke, M. J. (2009). Workplace safety: A meta-analysis of the roles of person and situation factors. *Journal of Applied Psychology*, *94*, 1103–1127. doi:10.1037/a0016172

Clarke, S. (2006). The relationship between safety climate and safety performance: A meta-analytic review. *Journal of Occupational Health Psychology*, *11*, 315–327. doi:10.1037/1076-8998.11.4.315

Clarke, S. (2010). An integrative model of safety climate: Linking psychological climate and work attitudes to individual safety outcomes using meta-analysis. *Journal of Occupational and Organizational Psychology*, *83*, 553–578. doi:10.1348/096317909X452122

Clarke, S. (2012). The effect of challenge and hindrance stressors on safety behaviors and safety outcomes: A meta-analysis. *Journal of Occupational Health Psychology*, *17*, 387–397. doi:10.1037/a0029817

Clarke, S., & Robertson, I. (2005). A meta-analytic review of the Big Five personality factors and accident involvement in occupational and non-occupational settings. *Journal of Occupational and Organizational Psychology*, *78*, 355–376. doi:10.1348/096317905X26183

Conchie, S. M. (2013). Transformational leadership, intrinsic motivation, and trust: A moderated-mediated model of workplace safety. *Journal of Occupational Health Psychology*, *18*, 198–210. doi:10.1037/a0031805

Cooper, M. D., Phillips, R. A., Sutherland, V. J., & Makin, P. J. (1994). Reducing accidents using goal setting and feedback: A field study. *Journal of Occupational and Organizational Psychology*, *67*, 219–240. doi:10.1111/j.2044-8325.1994.tb00564.x

Dai, H., Milkman, K. L., Hofmann, D. A., & Staats, B. R. (2015). The impact of time at work and time off from work on rule compliance: The case of hand hygiene in health care. *Journal of Applied Psychology*, *100*, 846–862. doi:10.1037/a0038067

Deepwater Horizon owner Transocean had poor safety culture, says coast guard. (2011). *AL.com*. Retrieved from http://blog.al.com/wire/2011/04/deepwater_horizon_owner_transo.html

Demerouti, E., Bakker, A. B., Nachreiner, F., & Schaufeli, W. B. (2001). The job demands-resources model of burnout. *Journal of Applied Psychology*, *86*, 499–512. doi:10.1037/0021-9010.86.3.499

Diefendorff, J. M., & Chandler, M. M. (2011). Motivating employees. In S. Zedeck (Ed.), *APA handbook of industrial and organizational psychology* (Vol. 3, pp. 65–135). Washington, DC: American Psychological Association.

Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly*, *44*, 350–383. doi:10.2307/2666999

Edwards, J. R. (1992). A cybernetic theory of stress, coping, and well-being in organizations. *Academy of Management Review*, *17*, 238–274. doi:10.5465/AMR.1992.4279536

Eklöf, M., & Törner, M. (2002). Perception and control of occupational injury risks in fishery. A pilot study. *Work & Stress*, *16*, 58–69. doi:10.1080/02678370110114694

Eklöf, M., & Törner, M. (2005). Participatory analysis of accidents and incidents as a tool for increasing safety behaviour in fishermen. A pilot intervention study. *Work & Stress*, *19*, 360–369. doi:10.1080/02678370500310218

Ford, M. T., & Tetrick, L. E. (2011). Relations among occupational hazards, attitudes, and safety performance. *Journal of Occupational Health Psychology*, *16*, 48–66. doi:10.1037/a0021296

Fruhen, L. S., Mearns, K. J., Flin, R., & Kirwan, B. (2013). Skills, knowledge and senior managers' demonstrations of safety commitment. *Safety Science*, *69*, 29–36. doi:10.1016/j.ssci.2013.08.024

Griffin, M. A., & Neal, A. (2000). Perceptions of safety at work: A framework for linking safety climate to safety performance, knowledge, and motivation. *Journal of Occupational Health Psychology*, *5*, 347–358. doi:10.1037/1076-8998.5.3.347

Hahn, S. E., & Murphy, L. R. (2008). A short scale for measuring safety climate. *Safety Science*, *46*, 1047–1066. doi:10.1016/j.ssci.2007.06.002

Halbesleben, J. R. (2010). The role of exhaustion and workarounds in predicting occupational injuries: A cross-lagged panel study of health care professionals. *Journal of Occupational Health Psychology*, *15*, 1–16. doi:10.1037/a0017634

Halbesleben, J. R., Leroy, H., Dierynck, B., Simons, T., Savage, G. T., McCaughey, D., & Leon, M. R. (2013). Living up to safety values in health care: The effect of leader behavioral integrity on occupational safety. *Journal of Occupational Health Psychology*, *18*(4), 395–405. doi:10.1037/a0034086

Halbesleben, J. R., Neveu, J. P., Paustian-Underdahl, S. C., & Westman, M. (2014). Getting to the "COR": Understanding the role of resources in conservation of resources theory. *Journal of Management*, *40*, 1334–1364. doi:10.1177/0149206314527130

Hansez, I., & Chmiel, N. (2010). Safety behavior: Job demands, job resources, and perceived management commitment to safety. *Journal of Occupational Health Psychology*, *15*, 267–278. doi:10.1037/a0019528

Haunschild, P. R., & Sullivan, B. N. (2002). Learning from complexity: Effects of prior accidents and incidents on airlines' learning. *Administrative Science Quarterly*, *47*, 609–643. doi:10.2307/3094911

Hechanova-Alampay, R., & Beehr, T. A. (2001). Empowerment, span of control, and safety performance in work teams after workforce reduction. *Journal of Occupational Health Psychology*, *6*, 275–282. doi:10.1037/1076-8998.6.4.275

Higgins, E. T. (2000). Making a good decision: Value from fit. *American Psychologist*, *55*, 1217–1230. doi:10.1037/0003-066X.55.11.1217

Hofmann, D. A., Jacobs, R., & Landy, F. (1995). High reliability process industries: Individual, micro, and macro organizational influences on safety performance. *Journal of Safety Research*, *26*, 131–149. doi:10.1016/0022-4375(95)00011-E

Hofmann, D. A., Morgeson, F. P., & Gerras, S. J. (2003). Climate as a moderator of the relationship between leader–member exchange and content specific citizenship: Safety climate as an exemplar. *Journal of Applied Psychology*, *88*, 170–178. doi:10.1037/0021-9010.88.1.170

Inness, M., Turner, N., Barling, J., & Stride, C. B. (2010). Transformational leadership and employee safety performance: A within-person, between-jobs design. *Journal of Occupational Health Psychology*, *15*, 279–290. doi:10.1037/a0019380

Kaplan, S., & Tetrick, L. E. (2011). Workplace safety and accidents: An industrial and organizational psychology perspective. In S. Zedeck (Ed.), *APA handbook of industrial and organizational psychology* (Vol. 1, pp. 455–472). Washington, DC: American Psychological Association.

Kark, R., Katz-Navon, T., & Delegach, M. (2015). The dual effects of leading for safety: The mediating role of employee regulatory focus. *Journal of Applied Psychology*, *100*(5), 1332–1348.

Kath, L. M., Magley, V. J., & Marmet, M. (2010). The role of organizational trust in safety climate's influence on organizational outcomes. *Accident Analysis & Prevention*, *42*, 1488–1497. doi:10.1016/j.aap.2009.11.010

Kelloway, E. K., Mullen, J., & Francis, L. (2006). Divergent effects of transformational and passive leadership on employee safety. *Journal of Occupational Health Psychology*, *11*, 76–86. doi:10.1037/1076-8998.11.1.76

Klein, H. J., Austin, J. T., & Cooper, J. T. (2008). Goal choice and decision processes. In R. Kanfer, G. Chen, & R. Pritchard (Eds.), *Work motivation: Past, present, and future* (pp. 101–150). New York, NY: Taylor & Francis.

Komaki, J., Barwick, K. D., & Scott, L. R. (1978). A behavioral approach to occupational safety: Pinpointing and reinforcing safe performance in a food manufacturing plant. *Journal of Applied Psychology*, *63*, 434–445. doi:10.1037/0021-9010.63.4.434

Lea, S. E. G., & Webley, P. (2006). Money as a tool, money as a drug: The biological psychology of a strong incentive. *Behavioral and Brain Sciences*, *29*, 161–209. doi:10.1017/S0140525X06009046

Leiter, M. P., & Robichaud, L. (1997). Relationships of occupational hazards with burnout: An assessment of measures and models. *Journal of Occupational Health Psychology*, *2*, 35–44. doi:10.1037/1076-8998.2.1.35

Leiter, M. P., Zanaletti, W., & Argentero, P. (2009). Occupational risk perception, safety training, and injury prevention: Testing a model in the Italian printing industry. *Journal of Occupational Health Psychology*, *14*, 1–10. doi:10.1037/1076-8998.14.1.1

Leung, M., Chan, I. Y., & Yu, J. (2012). Preventing construction worker injury incidents through the management of personal stress and organizational stressors. *Accident Analysis and Prevention*, *48*, 156–166. doi:10.1016/j.aap.2011.03.017

Li, F., Jiang, L., Yao, X., & Li, Y. (2013). Job demands, job resources and safety outcomes: The roles of emotional exhaustion and safety compliance. *Accident Analysis and Prevention*, *51*, 243–251. doi:10.1016/j.aap.2012.11.029

Locke, E. A., Feren, D. B., McCaleb, V. M., Shaw, K. N., & Denny, A. T. (1980). The relative effectiveness of four methods of motivating employee performance. In K. D. Duncan, M. M. Gruneberg, & D. Wallis (Eds.), *Changes in working life* (pp. 368–388). Chichester, UK: Wiley.

Lord, R. G., Diefendorff, J. M., Schmidt, A. M., & Hall, R. J. (2010). Self-regulation at work. *Annual Review of Psychology*, *61*, 543–568. doi:10.1146/annurev.psych.093008.100314

Lusa, S., Häkkänen, M., Luukkonen, R., & Viikari-Juntura, E. (2002). Perceived physical work capacity, stress, sleep disturbance and occupational accidents among firefighters working during a strike. *Work & Stress*, *16*, 264–274. doi:10.1080/02678370210163301

Madsen, P. M. (2009). These lives will not be lost in vain: Organizational learning from disaster in US coal mining. *Organization Science*, *20*, 861–875. doi:10.1287/orsc.1080.0396

Marcus, A. A. (1988). Implementing externally induced innovations: A comparison of rule-bound and autonomous approaches. *Academy of Management Journal*, *31*, 235–256. doi:10.2307/256547

Marks, M. A., Mathieu, J. E., & Zaccaro, S. J. (2001). A temporally based framework and taxonomy of team processes. *Academy of Management*

Review, *26*, 356–376. doi:10.5465/AMR.2001.4845785

Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, *50*, 370–396. doi:10.1037/h0054346

McLain, D. L. (1995). Responses to health and safety risk in the work environment. *Academy of Management Journal*, *38*, 1726–1743. doi:10.2307/256852

Mohammed, S., Ferzandi, L., & Hamilton, K. (2010). Metaphor no more: A 15-year review of the team mental model construct. *Journal of Management*, *36*, 876–910. doi:10.1177/0149206309356804

Morris, M. W., & Moore, P. C. (2000). The lessons we (don't) learn: Counterfactual thinking and organizational accountability after a close call. *Administrative Science Quarterly*, *45*, 737–765.

Morrow, P. C., & Crum, M. R. (1998). The effects of perceived and objective safety risk on employee outcomes. *Journal of Vocational Behavior*, *53*, 300–313. doi:10.1006/jvbe.1997.1620

Nahrgang, J. D., Morgeson, F. P., & Hofmann, D. A. (2011). Safety at work: A meta-analytic investigation of the link between job demands, job resources, burnout, engagement, and safety outcomes. *Journal of Applied Psychology*, *96*, 71–94. doi:10.1037/a0021484

Naveh, E., & Katz-Navon, T. (2015). A longitudinal study of an intervention to improve road safety climate: Climate as an organizational boundary spanner. *Journal of Applied Psychology*, *100*, 216–226. doi:10.1037/a0037613

Neal, A., & Griffin, M. A. (2004). Safety climate and safety at work. In J. Barling & M. R. Frone (Eds.), *The psychology of workplace safety* (pp. 15–34). Washington, DC: American Psychological Association.

Neal, A., & Griffin, M. A. (2006). A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. *Journal of Applied Psychology*, *91*, 946–953. doi:10.1037/0021-9010.91.4.946

Newman, S., Griffin, M. A., & Mason, C. (2008). Safety in work vehicles: A multilevel study linking safety values and individual predictors to work-related driving crashes. *Journal of Applied Psychology*, *93*, 632–644. doi:10.1037/0021-9010.93.3.632

Occupational Safety & Health Administration. (2015). *Business case for safety and health*. Retrieved from https://www.osha.gov/dcsp/products/topics/businesscase/costs.html

Parker, S. K., Axtell, C. M., & Turner, N. (2001). Designing a safer workplace: Importance of job autonomy, communication quality, and supportive supervisors. *Journal of Occupational Health Psychology*, *6*, 211–228. doi:10.1037/1076-8998.6.3.211

Pittman, T. S., & Zeigler, K. R. (2007). Basic human needs. In A. W. Kruglanski & E. T. Higgins (Eds.), *Social psychology: Handbook of basic principles* (2nd ed., pp. 473–489). New York, NY: Guilford Press.

Prentice-Dunn, S., & Rogers, R. W. (1986). Protection motivation theory and preventive health: Beyond the health belief model. *Health Education Research*, *1*, 153–161. doi:10.1093/her/1.3.153

Probst, T. M. (2002). The impact of job insecurity on employee work attitudes, job adaptation, and organizational withdrawal behaviors. In J. M. Brett & F. Drasgow (Eds.), *The psychology of work: Theoretically based empirical research* (pp. 141–168). Hillsdale, NJ: Lawrence Erlbaum Associates.

Probst, T. M. (2004). Safety and insecurity: Exploring the moderating effect of organizational safety climate. *Journal of Occupational Health Psychology*, *9*, 3–10. doi:10.1037/1076-8998.9.1.3

Probst, T. M. (2015). Organizational safety climate and supervisor safety enforcement: Multilevel explorations of the causes of accident underreporting. *Journal of Applied Psychology*, *100*(6), 1899–1907.

Probst, T. M., Brubaker, T. L., & Barsotti, A. (2008). Organizational injury rate underreporting: The moderating effect of organizational safety climate. *Journal of Applied Psychology*, *93*, 1147–1154. doi:10.1037/0021-9010.93.5.1147

Rasmussen, J. (1983). Skills, rules, and knowledge: Signals, signs, and symbols, and other

distinctions in human performance models. *IEEE Transactions on Systems, Man, and Cybernetics*, *13*, 257–266. doi:10.1109/TSMC.1983.6313160

Reason, J. (1990). *Human error*. Cambridge, UK: Cambridge University Press.

Rickett, B., Orbell, S., & Sheeran, P. (2006). Social-cognitive determinants of hoist usage among health care workers. *Journal of Occupational Health Psychology*, *11*, 182–196. doi:10.1037/1076-8998.11.2.182

Rubinsky, S., & Smith, N. (1973). Safety training by accident simulation. *Journal of Applied Psychology*, *57*, 68–73. doi:10.1037/h0034199

Rynes, S. L., Gerhart, B., & Minette, K. A. (2004). The importance of pay in employee motivation: Discrepancies between what people say and what they do. *Human Resource Management*, *43*, 381–394. doi:10.1002/hrm.20031

Schmidt, A. M., & DeShon, R. P. (2009). Prior performance and goal progress as moderators of the relationship between self-efficacy and performance. *Human Performance*, *22*, 191–203. doi:10.1080/08959280902970377

Schneider, B. (1975) Organizational climate: An essay. *Personnel Psychology*, *28*, 447–479. doi:10.1111/j.1744-6570.1975.tb01386.x

Schneider, B., & Reichers, A. E. (1983). On the etiology of climates. *Personnel Psychology*, *36*, 19–39. doi:10.1111/j.1744-6570.1983.tb00500.x

Schneyer, J., McNeill, R., & Roberts, J. (2013). *West Fertilizer Co. failed to disclose it had unsafe stores of explosive substance*. Retrieved from http://www.huffingtonpost.com/2013/04/20/west-fertilizer-company_n_3121110.html

Seo, H., Lee, Y., Kim, J., & Jee, N. (2015). Analyzing safety behaviors of temporary construction workers using structural equation modeling. *Safety Science*, *77*, 160–168. doi:10.1016/j.ssci.2015.03.010

Sharma, R., Yetton, P. W., & Crawford, J. (2009). Estimating the effect of common method variance: The method–method pair technique with an illustration from TAM research. *MIS Quarterly*, *33*, 473–490.

Smith, L., Totterdell, P., & Folkard, S. (1995). Shiftwork effects in nuclear power workers: A field study using portable computers. *Work & Stress*, *9*, 235–244. doi:10.1080/02678379508256559

Smith-Jentsch, K. A., Mathieu, J. E., & Kraiger, K. (2005). Investigating linear and interactive effects of shared mental models on safety and efficiency in a field setting. *Journal of Applied Psychology*, *90*, 523–535. doi:10.1037/0021-9010.90.3.523

Stride, C. B., Turner, N., Hershcovis, M. S., Reich, T. C., Clegg, C. W., & Murphy, P. (2013). Negative safety events as correlates of work-safety tension. *Safety Science*, *53*, 45–50. doi:10.1016/j.ssci.2012.09.003

Turner, N., Chmiel, N., Hershcovis, M. S., & Walls, M. (2010). Life on the line: Job demands, perceived co-worker support for safety, and hazardous work events. *Journal of Occupational Health Psychology*, *15*, 482–493. doi:10.1037/a0021004

Turner, N., & Parker, S. K. (2004). The effect of teamwork on safety processes and outcomes. In J. Barling & M. R. Frone (Eds.), *Psychology of workplace safety* (pp. 35–62). Washington, DC: American Psychological Association.

Tuysuz, G., Watson, I., & Smith-Spark, L. (2014). *Turkey mine search ends with 301 confirmed victims of fire*. Retrieved from http://www.cnn.com/2014/05/17/world/europe/turkey-mine-accident/

Van Eerde, W., & Thierry, H. (1996). Vroom's expectancy models and work-related criteria: A meta-analysis. *Journal of Applied Psychology*, *81*, 575–586. doi:10.1037/0021-9010.81.5.575

Vinodkumar, M. N., & Bhasi, M. (2010). Safety management practices and safety behavior: Assessing the mediating role of safety knowledge and motivation. *Accident Analysis & Prevention*, *42*, 2082–2093. doi:10.1016/j.aap.2010.06.021

Vroom, V. R. (1964). *Work and motivation*. New York, NY: Wiley.

Wallace, J. C., & Chen, G. (2005). Development and validation of a work-specific measure of cognitive failure: Implications for occupational safety. *Journal of Occupational and Organizational Psychology*, *78*, 615–632. doi:10.1348/096317905X37442

Wallace, C., & Chen, G. (2006). A multilevel integration of personality, climate, self-regulation,

and performance. *Personnel Psychology*, *59*, 529–557. doi:10.1111/j.1744-6570.2006.00046.x

Wallace, J. C., Paul, J. B., Landis, R. S., & Vodanovich, S. J. (2012). Occupational safety. In N. Schmitt (Ed.), *The Oxford handbook of personnel assessment and selection* (pp. 614–628). New York, NY: Oxford University Press.

Watson, G. W., Scott, D., Bishop, J., & Turnbeaugh, T. (2005). Dimensions of interpersonal relationships and safety in the steel industry. *Journal of Business and Psychology*, *19*, 303–318. doi: 10.1007/s10869-004-2230-2

Weick, K. E., Sutcliffe, K. M., & Obstfeld, D. (1999). Organizing for high reliability: Processes of collective mindfulness. In B. Staw & L. L. Cummings (Eds.), *Research in organizational behavior* (pp. 81–123). Greenwich, CT: JAI Press.

Westaby, J. D., & Lowe, J. K. (2005). Risk-taking orientation and injury among youth workers: Examining the social influence of supervisors, coworkers, and parents. *Journal of Applied Psychology*, *90*, 1027–1035. doi:10.1037/0021-9010.90.5.1027

Wiegmann, D. A., & Shappell, S. A. (2003). *A human error approach to aviation accident analysis: The human factors analysis and classification system*. Burlington, VT: Ashgate.

Zacharatos, A., Barling, J., & Iverson, R. D. (2005). High-performance work systems and occupational safety. *Journal of Applied Psychology*, *90*, 77–93. doi:10.1037/0021-9010.90.1.77

Zohar, D. (2002). Modifying supervisory practices to improve subunit safety: A leadership-based intervention model. *Journal of Applied Psychology*, *87*, 156–163. doi:10.1037/0021-9010.87.1.156

Zohar, D. (2011). Safety climate: Conceptual and measurement issues. In J. C. Quick & L. E Tetrick (Eds.), *Handbook of occupational health psychology* (2nd ed., pp. 141–164). Washington, DC: American Psychological Association.

Zohar, D., & Hofmann, D. A. (2012). Organizational culture and climate. In S. W. J. Kozlowski (Ed.), *The Oxford handbook of industrial and organizational psychology* (pp. 643–666). Oxford, UK: Oxford University Press.

Zohar, D., & Polachek, T. (2014). Discourse-based intervention for modifying supervisory communication as leverage for safety climate and performance improvement: A randomized field study. *Journal of Applied Psychology*, *99*, 113–124. doi: 10.1037/a0034096

Zohar, D., Tzischinski, O., & Epstein, R. (2003). Effects of energy availability on immediate and delayed emotional reactions to work events. *Journal of Applied Psychology*, *88*, 1082–1093. doi: 10.1037/0021-9010.88.6.1082

Author biographies

Jeremy M. Beus is an Assistant Professor in the Rucks Department of Management in the E. J. Ourso College of Business at Louisiana State University. He received his PhD in Industrial-Organizational Psychology from Texas A&M University. Jeremy's primary research interests include occupational safety, organizational climate, individual and team performance dynamism, and organizational socialization. His research has been published in journals such as the *Journal of Applied Psychology, Journal of Management, Journal of Organizational Behavior, Journal of Occupational Organizational Psychology, Journal of Business and Psychology,* and *Group and Organization Management.*

Mallory A. McCord is an Industrial-Organizational Psychology doctoral student at the University of Central Florida. Mallory's research interests include workplace mistreatment, personality, emotional intelligence, and occupational health. Her research has been published in journals such as the *Journal of Applied Psychology, Leadership Quarterly,* and *Industrial and Organizational Psychology: Perspectives on Science and Practice.*

Dov Zohar is a Professor in the William Davidson Faculty of Industrial Engineering and Management at the Technion – Israel Institute of Technology. He also serves as a Visiting Senior Scientist at the Liberty Mutual Institute for Safety Research. Dr. Zohar earned his PhD in Human Factors and Industrial-Organizational Psychology from the University of Maryland. In addition to his pioneering and ongoing research on safety climate, Dr. Zohar publishes research on the topics of leadership and organizational climate. He was awarded the American Psychological Association's Lifetime Achievement Award in 2008 and is a Fellow of the Society for Industrial and Organizational Psychology.