

# The effects of industry risk level on safety training outcomes: A meta-analysis of intervention studies

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## ABSTRACT

This *meta-analysis* quantitatively summarizes the effect of workplace safety training interventions on safety performance antecedents (safety motivation, knowledge, and climate) and safety performance (safety compliance and participation). One hundred unique samples from 90 published reports representing a wide variety of industries were included in this *meta-analysis*. While we found that safety training improved all the studied outcomes (d statistics ranging from 0.25 for safety participation to 0.87 for safety knowledge), the effect of industry risk-level was not consistent across the outcomes assessed. In high-risk industries (compared to low-risk industries), safety performance saw smaller gains (in line with Homeostasis Theory), but safety climate and motivation saw larger gains after safety training (contrary to the predictions of Homeostasis Theory) compared to low-risk industries.

## 1. Introduction

Fatalities, accidents, injuries, and illnesses in the workplace are costly occurrences that are a continual issue even in the modern workplace. According to the 2019 [Census of Fatal Occupational Injuries](#) 5333 fatal work injuries occurred just in the United States in 2019. This equates to over 14 workplace fatalities occurring each day. These fatalities not only impact the families who lose loved ones, but is also directly and indirectly costly for organizations. The direct cost to organizations of settling worker compensation claims is estimated to be 1 billion dollars per week in the United States. This does not include the numerous indirect costs such as lost productivity, accident investigations, and training of employee replacements ([Occupational Safety & Health Administration, 2018](#)). Fortunately, the incidences of nonfatal injuries and illnesses have been on a modest but continuous decline since 2012. It is possible that this decrease in nonfatal accidents is the consequence of increased interest in workplace safety by researchers and organizations alike. This interest is reflected in the increasing number of empirical studies explicitly investigating the effects of a variety of different occupational safety training interventions in the workplace.

Given the substantial impact workplace safety has on the lives of at-risk employees and the massive potential organizational costs, it is

imperative to understand the mechanisms involved in facilitating and fostering effective safety training interventions. First, this investigation sets out to create an updated and expanded synthesis of the safety training literature. The last comprehensive *meta-analysis* conducted in the safety literature concluded their search in 2008, and focused on performance and knowledge as outcomes ([Burke et al., 2011](#)). This study updates the *meta-analytic* estimates of the effect of safety training on a variety of safety training outcomes including safety performance (safety compliance and participation) and safety performance antecedents (safety climate, safety knowledge, and safety motivation). Safety compliance and participation were not included in the previous *meta-analysis*. In addition, this investigation uses the expanded safety training outcomes to examine an important moderator – the level of risk inherent to different industries, and its effects on the effectiveness of training interventions on the different safety-related training outcomes.

### 1.1. The components of organizational safety

Research investigating transfer of training has identified a variety of factors that influence the degree to which workplace training results in change of employees' behavior and workplace application. Training transfer is typically measured through the changes in individuals after being trained ([Kirkpatrick, 1987](#)). Research investigating workplace

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safety focuses on variety of indicators to evaluate the effectiveness of training. Some studies focus on employee safety performance through the improvement of safety related behaviors, while other studies focus on more attitudinal and perceptual indicators that are known to be antecedents of safety performance (such as: motivation, knowledge and safety climate).

Although accident and injury reduction is generally the first aspect of organizational safety that comes to mind, it is generally one of our most distal outcomes and is difficult to directly assess as a result of a generally low base rate (Clarke, 2006, 2010). Thus, there are far fewer intervention studies that examine accident and injury rates as their outcomes. We only found three studies that reported accidents and injuries, and this is the reason they were not included in this *meta*-analysis, as discussed further in the limitations section. Additionally, a lack of accidents is not a sufficient indicator of a safe work environment; instead, a high prevalence of accidents in the workplace is better understood as an indicator of a lack of safety within an organization (Beus, McCord, & Zohar, 2016). The work environment can be riddled with unsafe practices that have not yet culminated into accidents. The causes of organizational accidents tend to be complex and generally relies on multiple failures at the employee and organizational level. As a result, research investigating workplace safety generally focuses on more proximal indicators of safety, such as employee safety performance, and antecedents of behavior such as: safety knowledge, motivation to be safe, and both perceived individual level and aggregated to the group level safety climate. All of these factors have been shown in the organizational safety literature to impact accidents and injuries either directly or indirectly (Christian, Bradley, Wallace, & Burke, 2009), and they are therefore the focus of the current study.

### 1.2. Safety performance

Although the target of safety interventions can vary based on the specifics of the training method, one of the most common criteria for safety training is employee safety performance (Burke & Sockbeson, 2015). Safety performance is generally conceptualized in the literature through two broad categories of employee behaviors: Safety compliance and safety participation. In many ways, this model of safety performance first presented by Neal and Griffin (1997) mirrors the traditional job performance literature distinction between task performance and contextual performance (Borman & Motowidlo, 1997). Safety compliance behaviors include those that are expected or organizationally mandated (e.g., wearing safety gear), whereas safety participation subsumes a wide variety of behaviors such as promoting safety programs or taking the initiative to improve safety within the organization (Neal, Griffin, & Hart, 2000). In practice, this distinction manifests as the difference between essential behaviors that are necessary for employees to conduct their job tasks safely (i.e., safety compliance), and behaviors that work towards creating a work environment where safety is continually encouraged (i.e., safety participation).

This investigation will employ the well-established framework proposed by Neal and Griffin (1997) in an attempt to *meta*-analytically assess safety training interventions effect on the two main safety behavior types which we refer to as safety performance. As a result of a lack of studies, previous investigations were not able to investigate the differential impact of safety training on safety compliance and safety participation independently (Clarke, 2006, 2010).

### 1.3. Antecedents -Safety knowledge and motivation

Although the goal of safety training interventions is ultimately focused on improving employee safety behaviors, safety training often improves safety behaviors by first directly impacting a variety of attitudinal and perceptual antecedents of safety performance. Generally, researchers designing safety interventions decide at the onset what will be the primary target of their training. The safety literature has

identified numerous factors that consistently influence employee safety behavior such as behavioral expectancy, individual differences, employee knowledge of safety, and employee motivation to behave safely (Burke & Sockbeson, 2015; Zohar, 2010). Both employee safety knowledge and motivation have been found to be consistent antecedents to creating sustained change in safety behaviors.

In an attempt to model the antecedents of safety behavior, Neal and Griffin (2004) were among the first to conceptualize safety knowledge and safety motivation as key components. The inclusion of these factors was based on the Campbell, McCloy, Oppler, and Sager (1993) traditional model of job performance that suggested motivation, knowledge, and skills are the primary determinates of job performance.

### 1.4. Safety climate as a safety antecedent

Another important antecedent to organizational accidents and injuries is the climate of the organization (Luria, 2008, 2016; Zohar & Luria, 2004). Organizational climate is generally conceptualized as the shared employee perceptions concerning the practices and procedures of an organization that ultimately work to support and reward a certain set of behaviors (Luria, 2019; Schneider, Ehrhart, & Macey, 2013; Zohar & Luria, 2005). Since the conception of the organizational climate construct there have been numerous studies that have aimed to create climate constructs that are intended to support a particular subset of behaviors. Safety climate is an example of a domain-specific climate form that has received a great deal of empirical attention. Safety climate focuses on aspects of organizational policies, practices and procedures that promotes a safe work environment that is free of accidents and injuries (Luria, 2016; Neal et al., 2000; Zohar, 1980, 2010).

Generally, safety interventions are expected to improve all of the reviewed safety antecedents and safety performance variables. Therefore, the first hypothesis, replicating and expanding prior *meta*-analytic findings (Burke et al., 2011), suggests that safety training will improve the variety of safety outcomes it aims to improve:

**Hypothesis 1a and 1b.** *Safety training will improve safety antecedents (safety climate, motivation, knowledge) (hypothesis 1a), and safety performance (compliance, and participation) (hypothesis 1b).*

### 1.5. Risk as a moderator of the effect of safety training interventions

It is not surprising that the likelihood of experiencing an accident or being injured in the workplace depends on the occupation. Several researchers have suggested that inherent risk of hazardous event exposure in an occupation may interact with the way in which the safety training is administered to influence employee motivation (Burke et al., 2011; Griffin & Curcuruto, 2016; Neal & Griffin, 2004). Thus it is important to consider the level of exposure when evaluating the effects of interventions. Not only is occupation important, but industry is important as well considering that some industries expose employees to potentially dangerous situations that could put safety at risk.

We suggest a theoretical mechanism that explains the link between training and safety outcomes. Risk Homeostasis Theory (Wilde, 1998), suggests that inherently risky environments result in employees who naturally behave safely and therefore it is harder to increase safety outcomes for them. According to Homeostasis Theory, it is those employees who are in lower hazard industries whose safety behavior levels can be adjusted by emphasizing the risk.

### 1.6. Risk Homeostasis Theory

Risk Homeostasis Theory suggests that subjective and objective components of risk perception determine behavior decisions. Wilde (1998) assumes that risk-taking behavior is formed homeostatically by comparing a subjectively accepted degree of risk (target risk value) and an objective risk that is perceived in the environment. The model

assumes that people accept a certain amount of risk in daily life in exchange for an expected gain, which the intended actions seem to promise.

According to Wilde (1998), people compare the actual risk they perceive in a situation with the degree of risk that they are willing to accept. The degree of risk that respondents are willing to accept is called the target risk value. According to Homeostasis Theory, when the situation is risky, people behave in a safe manner naturally. That is, if individuals' objective degree of risk in a situation is high (for example employees who work in a high-risk industry), they will adapt their behavior accordingly (behave more safely) to compensate for the high environmental risk, so that in total, the target risk value is not surpassed. Wilde (1998) calls this the homeostasis principle. Thus, according to this theory, the behavioral change that safety trainings try to facilitate is already happening naturally in high-risk situations via the homeostasis principle, therefore safety interventions are likely to elicit only small changes in behavior. However, in low-risk situations, employees will not naturally perceive the environment as risky, and will allow themselves to behave in a riskier way (e.g., take shortcuts where safety is concerned). Therefore, an effective safety training intervention, one that lowers their target risk value and/or increases their perception of danger in the work environment stands a better chance of changing employees' safety outcomes, together with an understanding that even in a low-risk industry one needs to behave in a safe manner.

Many empirical studies demonstrated the natural behavioral change in high-risk situations. For example, studies regarding road safety demonstrated that drivers decrease risk taking in harsh weather conditions, such as rain and fog, and types of roads, such as winding (Chen et al., 2019; Hjelkrem & Ryeng 2016); decrease driving speed due to faulty sight as a result of cataract (Brémond et al., 2018), and decrease their speed when using their smartphone (Choudhary & Velaga, 2017; Cooper et al., 2009; Gauld et al., 2015; Saifuzzaman et al., 2015). In line with this theory, one could argue that similar tendencies to behave safely naturally will be evident in high-risk industries (even without training). This is because employees are more aware of the risk in their work environment, indicating they may already have better developed safety attitudes and perceptions (e.g., safety motivation, knowledge, and climate). Therefore, the effect of training on safety antecedents and safety performance is expected to be stronger in low-risk industries.

**Hypothesis 2:** *Industry risk level will moderate the effect of safety training on safety antecedents (safety climate, motivation, knowledge) (hypothesis 2a), and safety performance (compliance, & participation) (hypothesis 2b), such that the effect of training on safety antecedents and safety performance will be stronger in low-risk industries.*

### 1.7. Contributions of this Meta-Analysis

The purpose of this meta-analysis is to expand our current knowledge of the effectiveness of workplace safety training interventions in high-risk and low-risk industries. This investigation focuses on a core set of safety-related outcomes: Safety motivation, safety knowledge, safety compliance, safety participation, and safety climate.

Overall, this meta-analysis will add value by providing estimates of the relative effect sizes for safety training across five important safety outcomes. It also provides academics and practitioners insights into why safety training interventions may be more effective in some environments than in others. These findings will potentially help researchers and practitioners design effective safety training programs as well as provide support for safety training's long-term value for organizations and their employees.

## 2. Method

### 2.1. Database search

As illustrated in Fig. 1, the meta-analytic search and the procedure that was used to include and exclude identified studies using the Preferred Reporting Items for Systematic reviews and Meta-Analyses procedure (Moher et al., 2010). The Web of Science database was searched to identify potential articles for inclusion. Two searches were conducted, and the results of both searches were combined. The first search included the following phrases *employee, supervisor, workplace, worker, organization*, and *ergonomic* separated by the *or* Boolean operator. These phrases were conjoined to *safety training, safety intervention, accident prevention, error management*, and *error intervention* with the *and* Boolean operator. The second search included the following phrases *safety culture, safety climate, occupational injuries, safety outcomes, safety behavior*, and *safety leadership* separated by the *or* Boolean operator. These phrases were conjoined to *training or intervention* with the *and* Boolean operator. The combined search yielded 3174 sources.

In order to determine if the search was comprehensive enough to identify eligible studies an expert and notable researcher in safety interventions was consulted. He provided a list of 23 studies that to his knowledge would be eligible for inclusion. The results of the search were then evaluated to ensure that these studies were captured. All of 23 studies appeared in the search results.

### 2.2. Inclusion and exclusion criteria

In order to be eligible for inclusion a study needed to implement and evaluate some form of workplace safety training. These safety interventions included both within-subjects designs, between-subjects designs, experimental designs and quasi experimental designs. To be eligible for inclusion, interventions needed to be conducted within an organization with the express purpose of improving the safety of its employees. This could include seminars, lectures, leadership training, simulations, video-based training, communication techniques, behavioral modeling, or any other training conducted to promote worker safety. Studies also needed to include at least one relevant safety-related outcome variable in order to be considered eligible for inclusion. This included measures of safety behaviors, safety knowledge, safety motivation, or safety climate. All articles that met these criteria using samples of working adults were considered eligible for inclusion. Student samples were excluded.

Studies were excluded from analyses if they did not include a safety focused intervention, did not measure and report quantifiable safety-related outcomes, or did not provide a convertible effect size. Effect sizes must have been convertible to Cohen's *d*. Examples of statistics that can be converted include group means and standard deviations, *F* statistic, *t* statistic, correlation coefficients, and odds ratios. Studies that did not meet these criteria were excluded from eligibility (Fig. 1). All studies eligible for inclusion in this meta-analysis are included in the reference section and marked with an asterisk.

Three hundred and fourteen of the original 3174 studies were marked for inclusion based on a reading of the abstract or a brief review of the article text. From that subset, 90 studies and 100 samples were able to be coded. Studies that were excluded either did not provide convertible statistics, did not implement safety specific training, or English full text was unavailable.

### 2.3. Coding of articles

The goal of the coding process was to record the relevant effect sizes representative of the influence of occupational safety training on safety-related outcomes, as well as the industry (for the industry risk level moderator analysis). Additionally, intervention duration in hours (as a proxy for intervention intensity) was coded. This was done in order to

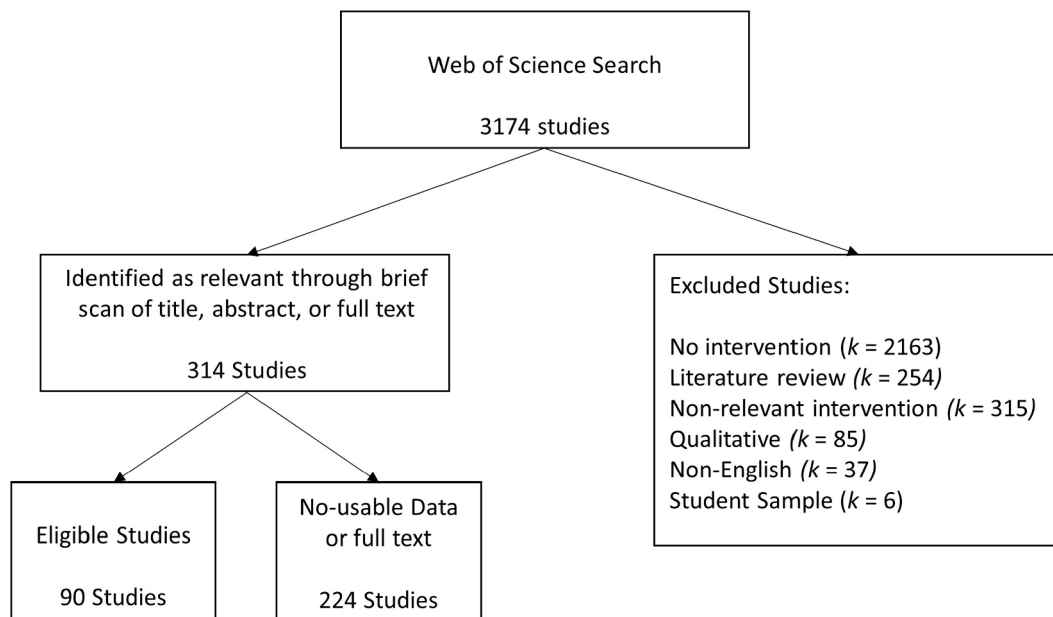


Fig. 1. Flow diagram of meta-analytic search and study inclusion protocol.

rule out an alternative explanation for differences between effect sizes in high risk and low risk industries, as it is likely that interventions would be more intensive in high-risk industries. Safety-related outcomes were coded into the following categories: Safety performance (compliance and participation), safety knowledge, safety motivation, and safety climate.

Given the nature of the types of indicators of many of the relevant outcomes the vast majority of empirical studies did not provide estimates of internal-consistency reliability. Many primary studies' measures consisted of single item metrics or formative behavioral composites that were not appropriate for calculating an alpha coefficient. Overall, not enough studies provided a measure of internal-consistency reliability to warrant corrections.

Furthermore, the experimental design varied between primary studies, some using a control group, others using pre-post scores, and some including both. When coding the effect sizes, if a study included scores on multiple time points after the intervention, the farthest one from the intervention was coded. For the  $d$  scores that were meta-analyzed, if there was a control condition, it was compared to the intervention condition to estimate  $d$ , if there was a pretest-posttest design with no control group, then the pre-intervention score was compared to the post-intervention score (59 of the samples). Next, we describe the coding scheme for our variables.

Industry risk level associated with each eligible study was coded by leveraging the occupational hazards outlined in the Bureau of Labor Statistic's occupational Injury and Illness Classification system (OIICS). The OIICS provides a comprehensive categorization of occupational hazards found across industries that lead to most common injuries. We created two categorizations of industries based on severity of hazards: Studies employing samples with an OIICS score of 1–5 were placed in the high-risk group, and those with an OIICS score of 6 or 7 were placed in the low-risk group. High-risk industries included exposure to violence by persons or animals, transportation incidents, fires and explosions, exposure to harmful substances or environments. This included industries such as healthcare which has a high incident rate of interpersonal violence and exposure to harmful substances. Low-risk industries included exposure to objects, slips and falls, and equipment or overexertion and bodily reactions as the primary hazard. This included industries such as food service, where there could be injuries primarily as a result of repetitive motion or frequent fall risks.

We explain the measurement of each variable and add an example of

item to illustrate the content of the studied variables:

### 2.3.1. Safety performance

If the behaviors are not explicitly stated to represent either safety compliance or safety participation, they were coded as representing either one by comparing the content of the measure to the definitions and conceptualization of these constructs described by Neal and Griffin (2004). An item, for example, for safety compliance is "I use the correct procedures and regulations for health and safety when carrying out my job", and an example item for safety participation is "I put in extra effort to improve employee health and safety in the workplace" (Bronkhorst et al., 2018).

## 2.4. Safety performance antecedents

### 2.4.1. Safety Knowledge

Declarative knowledge and procedural skills were coded as indicators of safety knowledge. Examples of metrics that were considered measures of safety knowledge were post-training scores on assessments measuring safety skills, self-reported mastery of safety skills, and self-reported perceptions of knowledge concerning safety practices or procedures. For example, a safety knowledge item for employees working in a kitchen was: "To safely cut food, employees should: [a] continue cutting if interrupted. [b] hold food loosely against the cutting board with the fingers held flat. [c] hold food firmly against the cutting board with fingers tucked under. [d] use as large a knife as is available." (Sinclair et al., 2003)

### 2.4.2. Safety Motivation

Measures of safety motivation generally consisted of self-reported indicators of motivation to be safe or self-rated assessments of an individual's belief in their abilities to be safe. Fewer studies provided direct measures of safety motivation than all other safety-related outcomes. An example item is "I think it is more important to work safely than it is to work quickly" (Mullen and Kelloway, 2009).

### 2.4.3. Safety Climate

Both perceived safety climate (measured in the individual level) and aggregated safety climate measures (measured in the team or organizational level), were coded into a single safety climate variable. Perceived safety climate consisted of any measure composed of

individual perceptions of the climate of their organization or their workgroup. Aggregated safety climate consisted of any measures that were aggregated to assess group or team-level safety climate. An item, for example is “To what extent in your unit “safety is an important value?”” (Naveh and Katz-Navon, 2015).

2.5. Meta-Analytic calculations

This investigation used the Metafor package in R to perform the meta-analyses (Viechtbauer, 2010). Random-effects and mixed-effects models were used in these analyses. Using fix-effects models would be inappropriate given the differences in the research methods and the sample characteristics that can introduce variability around the underlying true effect sizes. This variability around effect sizes is the primary focus of our moderator analyses. Random-effects models, in contrast to fixed-effect models, assumes that true effects are normally distributed rather than all studies sharing a common true effect (Hedges & Vevea, 1998). Mixed-effects models was used to evaluate the amount of heterogeneity in true effects resulting from the hypothesized moderator. The goal of these moderator analyses was to examine the extent to which the hypothesized moderator influenced the average effect size of safety training on our hypothesized outcomes (e.g., safety behavior). Maximum-likelihood was used as the variance estimator. Restricted maximum-likelihood has been found to be approximately unbiased, efficient and performs similarly to other popular estimators (Viechtbauer, 2005). These procedures resulted in an estimate of the true effect sizes of safety training on each outcome variable of interest, and the amount of variance accounted for by the proposed moderator variable. Given the expected lack of reported reliability data of many of the variables of interest, no corrections for unreliability were made. Effects sizes were weighted using inverse-variance weighting.

3. Results

3.1. Characteristics of eligible studies

Participants of the studies eligible for inclusion in this meta-analysis represented a wide variety of industries including healthcare, manufacturing, agriculture, non-profit, oil refining, power, railroad, food service, and lumber. The specific positions themselves were varied involving both individual contributors and people leaders. Overall, participants of these studies were diverse geographically. Individual studies eligible for inclusion were conducted in several countries, specifically: United States, Vietnam, The United Kingdom, Switzerland, Sweden, Portugal, Norway, New Zealand, The Netherlands, Malaysia, Korea, Israel, Iran, China, Germany, France, Columbia, and Canada. In total, across all dependent variables, 90 unique studies were eligible for inclusion with 100 unique samples. Across the studies that reported age and gender, the average age was 42.9 years (k = 39) and 34% were male (k = 49).

3.2. Effect of safety training on safety antecedents and performance

Table 1 summarizes the effect of safety training interventions on safety compliance, safety participation, safety motivation, safety

Table 1  
Summary of Intervention Effects for training Outcomes.

Outcome variable	K	N	$\bar{d}$	95% CI Lower	95% CI Upper	T	I <sup>2</sup>	Q
Safety Compliance	44	5860	0.52	0.32	0.73	0.66	96%	525.68*
Safety Participation	17	2419	0.25	0.07	0.43	0.33	88%	167.17*
Safety Motivation	9	510	0.78	0.36	1.19	0.59	89%	76.28*
Safety Knowledge	26	4268	0.87	0.61	1.13	0.65	96%	770.89*
Safety Climate	60	8489	0.32	0.21	0.42	0.38	91%	405.56*

Note. \* p < .05

knowledge, and safety climate. The table includes the point estimates of the weighted meta-analytic effect sizes ( $\bar{d}$ ) and 95% confidence intervals (CI) for all outcome variables. In addition, the following heterogeneity statistics are provided: The Q statistic (when significant, it indicates that the studies do not share the same true effect size), I<sup>2</sup> (observed variance that reflects real differences in effect sizes), and T (standard deviation of the true effect sizes).

The safety training interventions included in this meta-analysis significantly impacted both safety antecedents (hypothesis 1a) and safety performance (hypothesis 1b), providing support for Hypotheses 1a and 1b. The confidence intervals around the effects did not include zero for any of the safety-related training outcomes. The largest effect size was for safety knowledge ( $\bar{d}$  = 0.87, 95% CI: 0.61, 1.13), followed by safety motivation ( $\bar{d}$  = 0.78, 95% CI: 0.36, 1.19), and safety compliance ( $\bar{d}$  = 0.52, 95% CI: 0.32, 0.73). The effects for both safety climate ( $\bar{d}$  = 0.32, 95% CI: 0.21, 0.42), and safety participation ( $\bar{d}$  = 0.25, 95% CI: 0.07, 0.43), were markedly smaller in magnitude. However, given that there is overlap in the confidence intervals between all outcome variables, it is possible that these differences in effect size estimates are not meaningful. Caution should be exercised to avoid over interpreting differences in effect sizes among these variables.

3.3. Heterogeneity of studies

There was a great deal of heterogeneity or dispersion in the effect sizes for all of the key outcome variables. For all outcome variables, the Q statistics were significant and suggested that the studies included in this meta-analysis do not share the same true effect size (Table 1). The portion of the observed variance that reflects real differences in effect size (I<sup>2</sup>) ranged from 88% to 96%. Higgins, Thompson, Deeks, and Altman (2003) suggested that values above 75% can be considered as high. The large size of the observed I<sup>2</sup> values provided support for the existence of underlying moderating factors that could be driving these differences in reported effect sizes between studies. The moderation analyses are an attempt to explain some portion of this heterogeneity in effect sizes.

The standard deviations of the true effect sizes (T) were largest for the training outcome variables with the largest effect size estimates (i.e., safety knowledge, motivation, and compliance). This suggested that the dispersion of the effect sizes reported in the literature was greatest for these variables. However, the values of T were very large for all training outcomes. A funnel plot analysis was conducted to assess potential publication bias and no evidence was found (see Fig. 2 for one example). Each point in the plot represents an effect size with the vertical line indicating the mean d. There is no apparent asymmetry in the spread of the points around the mean, thus there is no evidence that only significant interventions were published. The remaining funnel plots are available upon request from the authors.

Furthermore, the reported results of the moderation analyses (Table 2) include an intercept and estimate for the moderation effect, the standard error of that estimate (SE), the number of studies included (k), the total proportion of the between-study variance explained by the moderator (r<sup>2</sup>), the omnibus test of the effect size estimate (QM), and the overall significance level of the moderator analysis (p). Furthermore, we

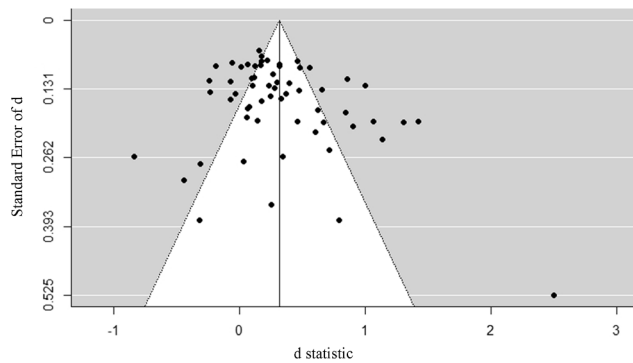


Fig. 2. Funnel Plot of Safety Climate Effect Sizes.

Table 2  
Moderation of Industry Risk Level on Safety Training by Training Outcomes.

Outcome variable	Intercept	Estimate	SE	K	r <sup>2</sup>	QM	p
Safety Compliance	0.97	-0.59	0.23	44	0.13	7.11	0.01
Safety Participation	0.74	-0.61	0.16	17	0.56	13.91	0.00
Safety Motivation	0.39	0.73	0.35	9	0.36	4.35	0.04
Safety Knowledge	0.46	0.29	0.76	27	0.00	0.63	0.73
Safety Climate	0.01	0.35	0.16	60	0.05	4.40	0.03

present the meta-analytic effect sizes ( $\bar{d}$ ) and 95% confidence intervals (CI) for all outcome variables separately for the high risk and low risk industries (Table 3).

### 3.4. Moderation analyses by industry risk level

Industry risk level significantly moderated the effect of safety training on four of the five training outcome variables (Table 2): Both measures of safety performance (safety compliance, safety participation), and two of the three measured safety antecedents (safety motivation, and safety climate). The direction of the effect was not consistent across outcomes providing only partial support to hypothesis 2. Supporting hypothesis 2b, the effect of safety training on both forms of safety performance (i.e., safety compliance and participation) were stronger in low-risk industries (moderation effect estimates of -0.59 and -0.61, respectively). In contrast to hypothesis 2a, the effect of safety training on safety antecedents (motivation and safety climate) was stronger in high-risk industries (moderation effect estimates of 0.73 and 0.35, respectively). There was no moderation effect on safety knowledge. The meta-analytic estimates for the effect sizes are presented separately for low and high-risk industries in Table 3 for all outcomes that had a significant moderator effect. The forest plot of all the outcomes by the moderator (risk) are presented (See Figs. 3-6). The plot separates the high-risk (top of the plot) from low-risk (bottom of the plot) studies. Each plot shows the effect size (square dot horizontal

Table 3  
Intervention Effects at Low and High Industry Risk Level

Outcome variable	$\bar{d}$	SE	95% CI Lower	95% CI Upper	$\bar{d}$	SE	95% CI Lower	95% CI Upper
	Low Risk				High Risk			
Safety Compliance	0.98	0.21	0.57	1.38	0.38	0.11	0.16	0.60
Safety Participation	0.74	0.15	0.45	1.02	0.13	0.07	-0.02	0.27
Safety Motivation	0.39	0.25	-0.11	0.88	1.12	0.24	0.64	1.60
Safety Climate	0.01	0.15	-0.29	0.31	0.36	0.06	0.25	0.47

Note. Industry level risk did not moderate the intervention effect size on knowledge and therefore the effects are not shown separately for this outcome.

position), confidence intervals (horizontal bars), and sample size (size of the square dot). They are arrayed from top to bottom by size of  $d$ . As seen in Table 3 and Figs. 3-6, the effects of safety training interventions on safety motivation and climate were smaller and not significantly different from zero in low-risk industries. For safety participation, the intervention effect was not significantly different from zero in high-risk industries. The effects on safety compliance are significant in both low and high-risk industries but are stronger in low-risk industries.

### 3.5. Additional analyses

To eliminate an important alternative explanation for the moderator effect, we conducted an additional analysis of the intervention time in hours (as a proxy for intervention intensity). This is because it is likely that in high-risk industries, more resources are invested in safety training, and we wanted to see if intervention intensity, rather than industry risk level, moderated the effects of the interventions. First, we examined the link between risk level and intervention intensity. We found that there was a small and only marginally significant correlation between industry risk level (OIICS; higher score indicating lower risk) and intervention intensity (hours of actual training):  $r = -0.23, k = 68, p = .06$ . This indicates that when the industry risk level is higher, interventions may be more intense, at least in the cases where the hours of actual training were reported. Next, we conducted the moderation analyses again, this time with hours of training as a continuous moderator instead of risk level, and found it was not a significant moderator of any of the relationships (see supplementary materials for results of this analysis). Therefore, the moderator effect of industry risk level is likely not the result of the intensity of training.

We also wanted to assess the effect of the rigor of the study design, that is, whether the study used an intervention-control group design or a pretest-posttest design, on the meta-analytic estimates. No significant differences were found for safety compliance, safety participation, safety knowledge, and safety climate (moderation effect estimates of 0.12, -0.37, -1.38, and -0.17, respectively, all  $p > .05$ ). There was also no significant effect for safety motivation (moderation effect estimate = 0.66,  $p > .05$ ), but given the small number of studies that reported this variable ( $k = 9$ ), this analysis is likely not reliable. Overall, these results suggest that the reported effects are relatively consistent across the different intervention study designs.

## 4. Discussion

The goal of the current meta-analysis was to understand how industry risk influences the effectiveness of safety training. Based on 100 unique samples from 90 different intervention initiatives we found that safety training interventions have a statistically significant impact on all of the key training outcome variables assessed (safety performance, and safety performance antecedents: safety climate, motivation and knowledge), fully supporting hypothesis 1. However, we found a large amount of dispersion among effect sizes, and that industry risk moderated the effect of safety training for all studied variables except for safety knowledge.

The magnitude of the effect sizes of safety training interventions on the training outcome variables generally followed the expected pattern.

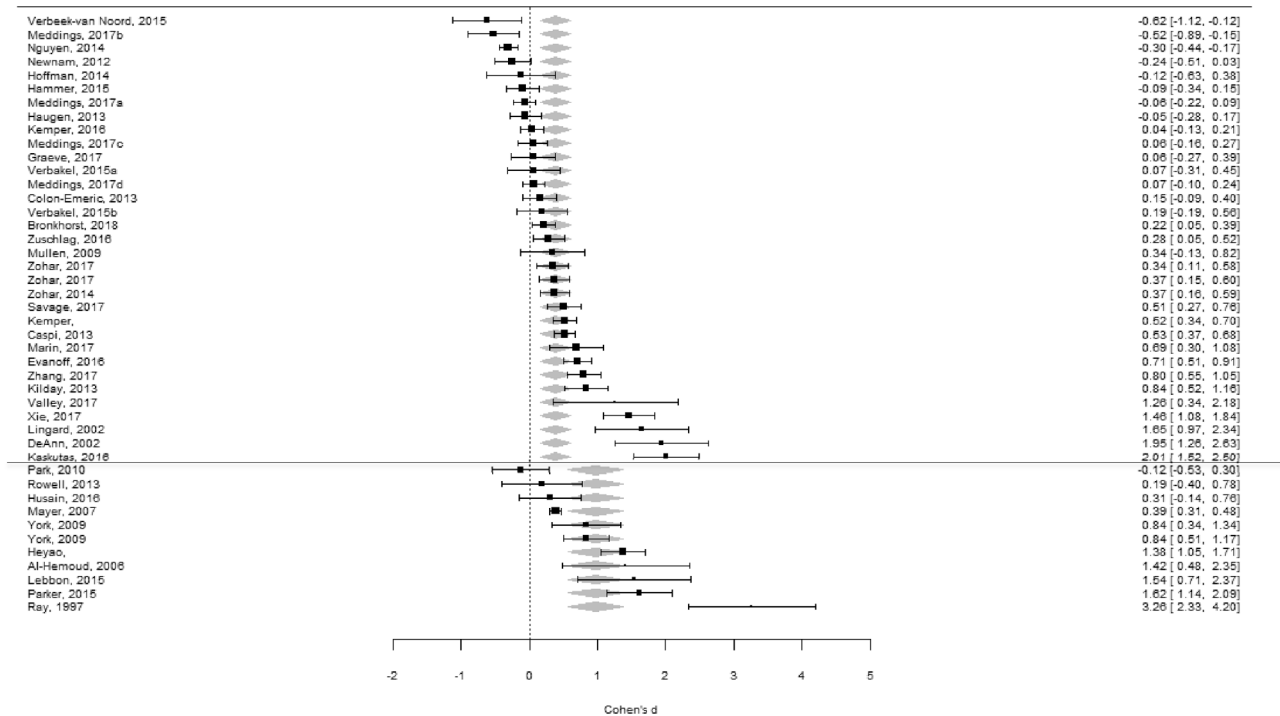


Fig. 3. Forest Plot of the Moderation Effect of Risk-Level on Safety Compliance (High-Risk Group is on Top and Low-Risk Group is on Bottom of the Plot).

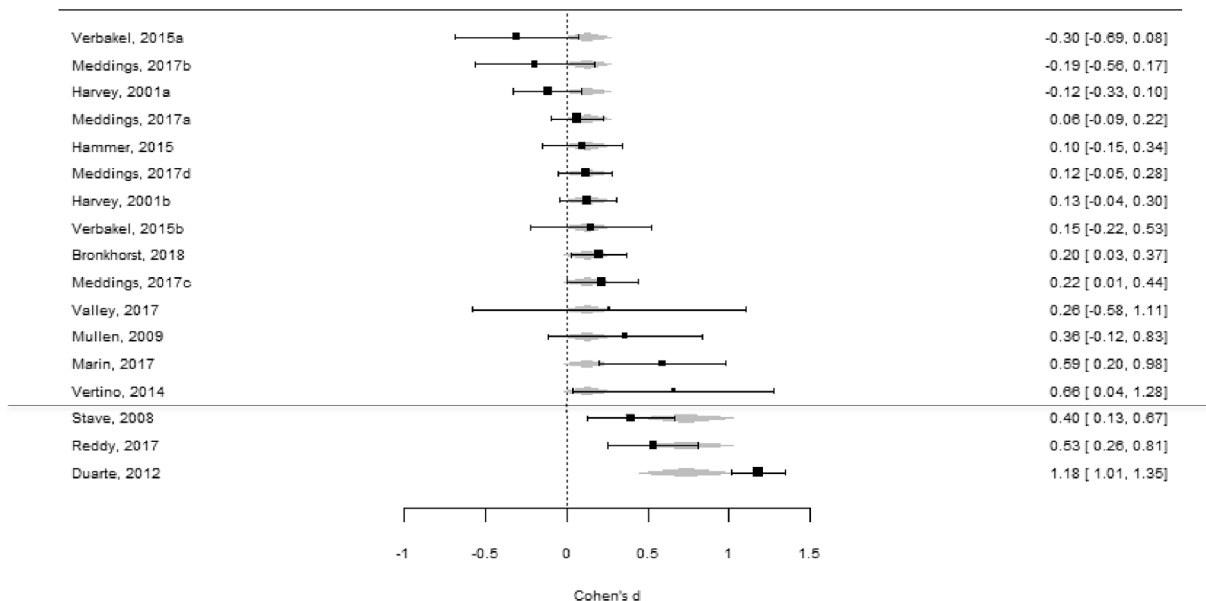


Fig. 4. Forest Plot of the Moderation Effect of Risk-Level on Safety Participation (High-Risk Group is on Top and Low-Risk Group is on Bottom of the Plot).

Both safety motivation and safety knowledge saw the largest benefits from safety training interventions. This was followed by the safety compliance portion of safety performance. Finally, safety climate saw the smallest benefit from safety training. This pattern of differences in effect sizes generally supported the mapping of the most prominent model of workplace safety onto Kirkpatrick's levels of training evaluation (Kirkpatrick, 1987). Trainee reactions and learnings (i.e., motivation and knowledge) had the biggest gains, followed by performance (i.e., safety compliance), and broader organizational outcomes (i.e., safety climate). The only component that did not map onto this model was the effect of safety training on safety participation. The impact of safety training interventions on safety participation was the smallest out of all

the safety-related outcome variables. This is likely a result of the added effort required to engage in safety participation behaviors. Whereas safety compliance is focused on engaging in organizationally mandated rules or best practices, safety participation requires going above and beyond job requirements to promote safety programs or to take a more involved initiative with developing safety (Clarke & Ward, 2006). Overall, safety training interventions had an impact on a variety of key safety-related variables.

An important consideration when evaluating the effect size of safety training on safety related variables is the large degree of heterogeneity across studies. Even though a large degree of heterogeneity was expected given the diverse methods and approaches to safety training

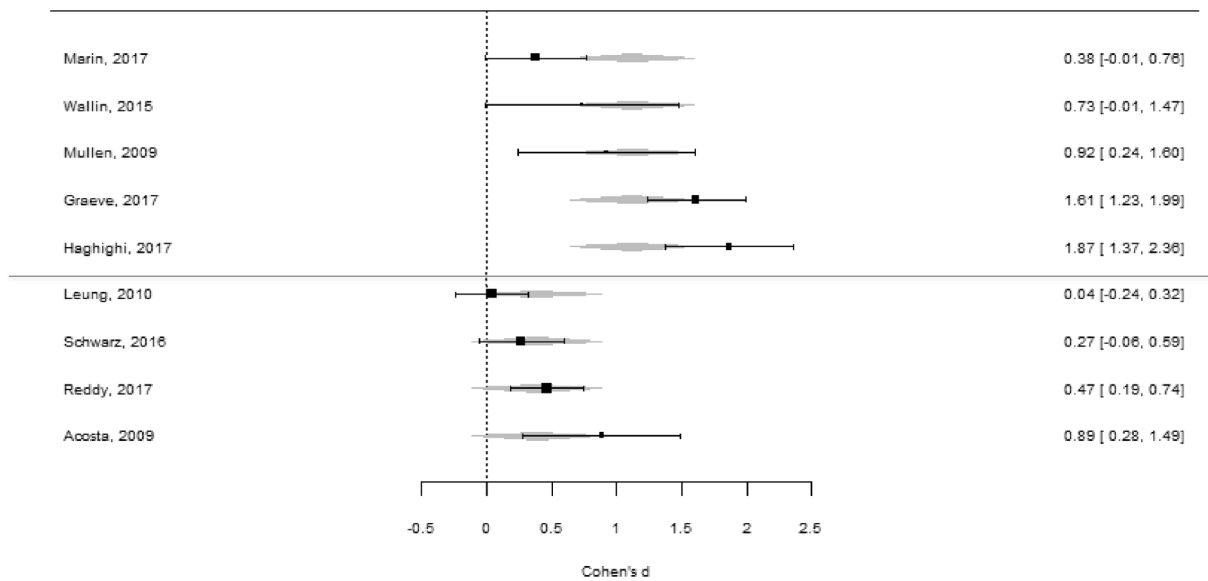


Fig. 5. Forest Plot of the Moderation Effect of Risk-Level on Safety Motivation (High-Risk Group is on Top and Low-Risk Group is on Bottom of the Plot).

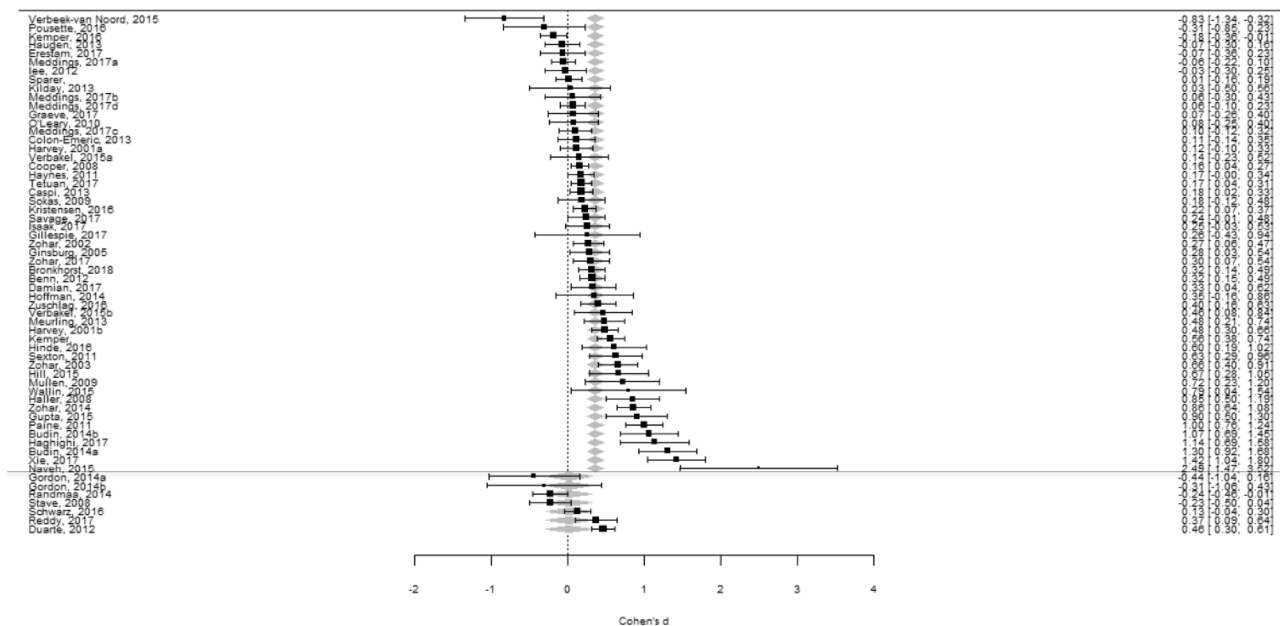


Fig. 6. Forest Plot of the Moderation Effect of Risk-Level on Safety Climate (High-Risk Group is on Top and Low-Risk Group is on Bottom of the Plot).

conducted in the literature, this study found that there was little evidence of consistency across studies.

In line with the predictions of Homeostasis Theory, we found that the effect of safety training on safety performance (compliance and participation) is stronger in low-risk industries than in high-risk industries. However, we found that the effect of safety training on safety antecedents (motivation and safety climate) is stronger in high-risk levels than in low-risk levels, opposite to our hypothesis (and predictions based on Homeostasis Theory). It is possible that the inconsistent direction of the moderations effects suggests that there is another theoretical explanation for how interventions affect attitudinal outcomes. Homeostasis Theory mostly focuses on cost benefit considerations for behavior and therefore it stands to reason that it explained the studied interventions effect on performance better than on attitudes. However, Homeostasis Theory may not be suited to capture the emergence of attitudes as a result of safety interventions.

A possible alternative theoretical explanation for the emergence of

attitudes is Sensemaking Theory (Weick, 1993). Sensemaking theory explains how employees make sense of their environment. It clearly states that congruence between different parts of the complex environment (i.e., organizational HR activities and the organizational context) helps employees to make sense of their environment and develop shared attitudes (Weick, 1993, 1995). Sensemaking is a process of social construction in which employees try to interpret clues provided by the environment by interacting with each other (Isabella, 1990; Weick & Roberts, 1993). According to sensemaking theory, when there is no congruence between different parts of the organizational system, then employees may find the environment complex and conflicting and therefore their ability to make sense of the situation will be limited. However, in case of congruency between different parts of the environment, shared attitudes are more likely to emerge.

In the current study we focus safety training interventions. These training interventions often communicate that safety behavior is important in order to prevent accidents. The message communicated in

the safety training should have better congruence with the work environment for employees in high-risk industries. In such industries, the probability of being injured is higher than in low-risk industries, and the warnings communicated in safety training regarding safety risks are better aligned with how the employees perceive the environment than in low-risk industries. Therefore, in high-risk environments employees are more likely to understand the need for safety and adopt pro safety attitudes communicated in the training (e.g., safety climate and motivation). However, in low-risk industries the message communicated in the safety training may have low congruence with the external environment the employees are exposed to. Employees in low-risk environment may perceive that the chances for accidents or injuries to occur are very low and are not aligned with the need for safety communicated in the safety training.

Thus, sensemaking theory can explain why safety training had a better effect on attitudinal variables in high-risk environments than in low-risk environments. It is more likely that the pro safety arguments communicated in the safety training will be aligned with other organizational cues (the employees will find it easy to accept that they are operating in a risky situation). This should, according to this theoretical mechanism, facilitate change in safety outcomes more than in low-risk environments.

Furthermore, we were able to eliminate an important alternative explanation for why interventions had a stronger effect on the safety attitudinal variables (motivation and safety climate) in high-risk environments. Specifically, although interventions tended to be marginally more intensive in terms of hours of actual training, this intensity did not explain a significant amount of heterogeneity in the effect sizes on safety interventions. We are therefore able to say that risk, but not training intensity, results in greater gains to motivation and safety climate in high-risk industries, where these changes are more crucial.

#### 4.1. Practical implications

This *meta*-analytic review has several important implications. First, it provides a detailed summary of the current state of the safety training literature by focusing entirely on interventions intended to increase workplace safety. The results of this study summarize the effect sizes of safety training interventions on key safety-related outcome variables that are of interest to researchers and practitioners alike. Overall, the results of the analyses found a greater amount of variability than was expected. These results support a strong case for the importance of careful care and consideration during the development and creation of safety training interventions.

The second key take away from this investigation can be found in the moderator analyses. Through the testing of industry risk-level as a moderator, we explained some of the substantial heterogeneity in effect sizes. When designing future safety training interventions both researchers and practitioners should consider the industry risk-level and design the intervention and effectiveness measures accordingly, especially considering that for most outcomes, the interventions were not equally effective under all conditions. For example, in low-risk industries interventions researchers and practitioners should increase sense-giving efforts of explaining the gap between the actual risk the employee experience and the need to invest time and energy in prevention of accidents.

Another important take away from the moderator analysis is that much unexplained variance remains. This suggests that there are other potential factors that should be considered in the design of safety training interventions and tested as moderators.

#### 4.2. Limitations and future directions

Although this study provides a summary of the effects of safety interventions on most key safety variables, there are limitations to this investigation that need to be considered when interpreting the results.

Like the many *meta*-analyses attempting to evaluate the effect of moderators, the majority of the analyses were statistically under-powered. This was a result of the small numbers of studies available in the literature at some of the levels of the moderator evaluated, which in this study resulted in dichotomizing the moderator variable into high- and low-risk. As more primary studies are conducted and published, future researchers will have a greater amount of statistical power to be able to detect differences.

Future research should also continue to explore more contextual factors that may impact the efficacy of safety training interventions. The analyses presented here found differential impact of safety training based on the risk-level of the industry. There are a variety of other contextual or organizational factors that could be explored that may explain a portion of the variance among effect sizes. One potential factor is job specific risk level, as it is possible that within the same industry or organization, some jobs (e.g., assembler) will be riskier than others (e.g., office assistant). This study attempted to get at this factor by evaluating studies based on their OIICS rating, but relied on an imperfect form of aggregation. Another area for future research could be investigating other group-level or climate-level constructs beyond safety climate, such as safety leadership (Pilbeam et al., 2016) and psychological safety climate (Bradley et al., 2012), helping us gain a better understanding of the contextual factors that impact safety training effectiveness. For example, other climate forms have gained popularity in recent years, and it is possible that a variety of organizational climates spanning more diverse domains can be important when designing and implementing safety training interventions. Furthermore, while we found a main effect for safety intervention on knowledge, risk-level did not moderate this effect, despite the significant heterogeneity of this main effect. While risk-level does not explain this heterogeneity, there are other potential moderators, not explored here, that could explain why interventions sometimes resulted in greater increase in knowledge than other times.

The current study was limited in the measurement of safety performance. As most studies employed the distinction between safety compliance and safety participation (Neal, Griffin & Hart, 2000), the current analysis focused on these frequently used safety performance measures. However, recent research on safety behavior includes sub-components of compliance and participation. For example, according to Curcuruto, Conchie, and Griffin, (2019a) and Curcuruto, Parker, and Griffin, (2019b) safety participation is composed of an affiliative component (i.e. helping, stewardship behaviors) and a challenging oriented component (i.e., voice, initiating safety related change). Safety compliance is composed of surface (behaviors intended to meet organizational requirements) and deep (behaviors intended to maintain workplace safety and reduce risk) compliance (Hu, Yeo, & Griffin, 2020). Future safety training studies should make the distinction between them and test the effectiveness of training on each specific sub-component of the safety performance.

Finally, this *meta*-analysis was restricted to safety variables which were included in sufficient primary studies. Unfortunately, only three studies that we could find reported the effects of a safety intervention on accidents or injuries. The Yu et al. (2017) intervention resulted in a significant decrease in accidental injury rates in high-risk (factory) settings. In another high-risk settings (i.e., carpentry), a safety outreach intervention resulted in a non-significant reduction in injury claims (Schoenfisch et al., 2017). Finally, an occupational safety and health education prior to the start of the job resulted in significantly fewer workplace injuries in jobs with varying risk levels (service and production jobs) two years later (Boini et al., 2017). This limited number of studies made it impossible to include accidents and injuries, the main safety outcome, in the *meta*-analysis. Considering their generally low base rate (Clarke, 2006, 2010), it is understandable why most safety studies do not include accidents and injuries. However, we encourage future researchers to report these outcomes whenever possible.

## 5. Conclusion

The present study drew on the safety training literature to investigate the influence of safety training interventions on key safety-related outcomes. This study also attempted to identify an important factor that explains some of the variation in the efficacy of different safety training interventions (industry risk level). Overall, the results of this meta-analysis suggest that safety training interventions have a positive impact on employees in terms of their safety compliance, safety participation, safety motivation, safety knowledge, and safety climate.

Although safety training impacted a wide variety of safety-related outcomes, the effect of safety training on safety-related outcomes varied widely across studies. Some of this variance was explained by the moderator - industry risk-level. However, a substantial amount of heterogeneity among effect sizes remains unexplained. This suggests that a great deal of care is needed when designing and implementing safety training interventions. It is likely that choices that are made during the development and implementation of safety training interventions can be pivotal in maximizing the impact and creating lasting change on individuals' safety in the workplace.

## CRedit authorship contribution statement

**Derek Hutchinson:** Conceptualization, Investigation, Methodology, Formal analysis, Data curation, Writing – original draft, Supervision. **Gil Luria:** Conceptualization, Writing – original draft, Supervision. **Shani Pindok:** Conceptualization, Validation, Writing – review & editing. **Paul Spector:** Conceptualization, Writing – review & editing, Supervision.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssci.2021.105594>.

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\*The list of references used in the meta-analysis itself is available upon request.

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