1.1.1. Conceptualization of Safety Culture and Safety Climate

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Conceptualization of Safety Culture and Safety Climate

Safety researchers and industry experts exert a great deal of efforts into studying, understanding, and applying the concepts of safety culture and safety climate to improve employees' safety performance. These concepts are commonly used by industry members as leading indicators that assist in preventing and predicting injuries and accidents in the workplace (Guldenmund, 2000). Both safety culture and safety climate involve studying the human aspects of safety and both concepts are associated with decreased injuries and accidents within organizations (Cooper & Phillips, 2013; Wang & Lin, 2012). Safety culture and safety climate are also associated with a wide variety of beneficial outcomes, including increased job satisfaction, decreased employee turnover, decreased job stress, and increased quality of production (Gyekye & Salminen, 2010; McCaughey, et al., 2013; Wells, 2010).

Although researchers argue on exactly how to define safety culture and climate (to be discussed), *safety culture* is generally defined as the assembly of underlying assumptions, beliefs, values, attitudes, and behaviors of organizational members regarding the safety of their organization (Edwards & Armstrong, 2013). These underlying beliefs and assumptions are both implicit and explicit whereby norms are so deeply ingrained within the organization that employees no longer consciously think about them. Safety culture is a long-lasting phenomenon that can be difficult to change (Bentley & Tappin, 2010). Conversely, *safety climate* is defined as employees' safety perceptions at a specific point in time (Fugas, Silva, & Melia, 2012). Unlike safety culture, employees' perception of safety climate is heavily dependent on the contextual setting and is often associated with the superficial perceptions of safety (Hon, Chan, & Yam, 2012).

Applied researchers study ways to accurately assess and improve safety culture and safety climate, and to predict outcomes associated with these constructs. Safety culture and safety climate are most often assessed using survey questionnaires; however, there are a number of qualitative methods that can also be used to assess these constructs (e.g., interviews, focus groups, and observation; Frazier et al., 2013; Freeth et al., 2012). In addition, individuals or subcultures within an organization may experience differences in their perceptions of safety culture and safety climate due to unique individual or contextual differences (Adjekum, 2013; Craig, Das, & Khago, 2010).

The question that guided our scoping review was: "How do safety culture and safety climate impact industry and how can they be improved?

Method

Search strategy. Unlike most topics, articles selected for this chapter were not retrieved using a standard database search and formal search strategy. This is because it was originally thought that the concepts of safety culture and safety climate would be embedded within *all* topics. However, given, the multitude of existing literature, it became apparent that the concepts of safety culture and safety climate required their own topic chapter in addition to being mentioned in related chapters. Consequently, articles with the term "safety culture" or "safety climate" within their title were extracted from the pool of literature obtained through all other search strategies conducted by the U of S team (i.e., already included and screened within other U of S topics).

Keyword searches among all articles included under existing factors identified 135 articles with

"safety culture" in the title and 126 with "safety climate" in the title. Once duplicates and irrelevant articles were excluded, 116 articles remained. Over two thirds of the included articles came from 1.7 Other Organizational factors, but articles were included from nearly all topics.

Screening strategy. Articles ultimately included in this chapter were first screened within their original topic; thus, irrelevant records (e.g. non English), irrelevant mediums (e.g., book reviews, letters to editor, etc.), and irrelevant safety domains (e.g., sexual risk taking, gambling, etc.) were already removed. Articles were screened for relevance based on the inclusion/exclusion criteria listed in Table 1. Most articles excluded for this chapter were ultimately included within their original topic.

Table 1. Safety Culture and Climate Inclusion/Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
• Deals with conceptualization, understanding or measurement of safety culture or safety climate • Relationship between safety culture and safety climate • Predictors of safety culture or safety climate • Outcomes of safety culture or safety climate (i.e., accidents, injuries, etc.) • How culture of origin impacts safety attitudes • General research on how to develop or strengthen a safety culture/climate (i.e., broader than a single factor).	• Newspaper articles, editorials, opinion articles, or books chapters/reviews. • It has no psychological findings (i.e., just reporting a story or facts about the industry like safety statistics) • Any population other than adults (i.e., over 18) • Measures of safety culture/climate for the purpose of studying its relationship to safety factors or variables other than outcome factors of accidents, injuries, etc. (i.e., the article is better included within its original topics; e.g., safety culture and communication) • Includes safety culture/climate as one of many variables affecting another outcome (i.e., the article is better included within its original topic)

Results

Description of included articles. A brief summary of all articles including the location, population studied, main issue addressed, comparison group, and primary outcomes is provided in Appendix G. The following is an overview of included articles.

Table 2. Safety Culture and Climate Number of articles by types, country, and population

Type of Publication:	**Country of Publication:**	**Population Studied:**

- 8 summary discussions
- 6 theoretical reviews
- 4 meta-analyses
- 2 scoping reviews
- 97 original research articles
  - 83 surveys
  - 19 qualitative studies (i.e., interviews, focus groups, observation, case study)
  - 1 archival study
	- 39 USA
	- 10 Australia
	- 8 Malaysia
	- 7 UK, Japan, Taiwan,
	- 6 Norway, Spain, Sweden
	- 4 Italy
	- 3 China, Netherlands
	- 2 Brazil, Denmark, Iran, Ireland, India, Philippines
	- 1 Algeria, Austria, Belgium, France, Germany, Ghana, Iceland,
		- 27 processing, manufacturing, construction
		- 11 hospital and pharmacy
		- 10 oil and gas
		- 6 offshore vessels
		- 5 aviation
		- 5 nuclear power
		- 5 firefighting
		- 4 railway
		- 4 transportation
		- 2 university
		- 1 mining

	Israel, Mexico, New Zealand, Poland, Romania, South Africa, South Korea, Ukraine, all continents	- 1 human resources - 1 navy - 1 telecommunications - 1 restaurant - 1 hotel service - 1 marine industry - 14 various industries - 8 general employees (i.e., did not distinguish between job type or industry)

Description of identified factors. Based on an analysis of the selected articles conducted in Stage 1, eight themes of organizational safety culture and climate factors emerged: conceptualization of safety culture; conceptualization of safety climate; relationship between safety culture and safety climate; assessment of safety culture and safety climate; individual differences in safety culture and climate; facilitators and barriers of safety culture and climate; outcomes of safety culture and safety climate; and, safety culture and climate interventions. The primary results and potential applications of each identified factor are discussed. All definitions of concepts as used in the current literature are provided in Appendix H.

Conceptualization of Safety Culture. Ten articles were related to the conceptualization of safety culture. The concept of safety culture was first coined after the Chernobyl nuclear explosion in 1986 (Schmid, 2011). Since that time an abundance of definitions for safety culture was developed, which created confusion among researchers on how safety culture should be understood and what dimensions should be included within the concept (Reiman & Rollenhagen, 2014). This conceptual confusion is also reflected in the abundance of models and frameworks that have been developed in order to better understand the nature of safety culture (Edwards & Armstrong, 2013). Three different theoretical approaches applied to safety culture (Guldenmund, 2010) and various dimensions of safety culture are discussed in the literature (Bentley & Tappin, 2010).

Origin and definitions of safety culture. All articles agree that the concept of safety culture was coined during the investigation into the Chernobyl nuclear explosion in 1986 (Schmid, 2011). This new concept was needed to encompass the underlying safety attitudes, beliefs, behaviors, and assumptions regarding safety that occur at the individual and organizational levels. It demonstrated that safe technology is often not enough to prevent injuries and accidents; industry must also look at the human factors (Schmid 2011). However, as the concept of safety culture continued to be studied, an increasing number of researchers developed their own definitions (see Table 3). The lack of a clear and consistent definition of safety culture creates confusion and limits the degree to which validity and reliability can be assessed within and between organizations to prevent and predict injuries and accidents (Reiman & Rollenhagen, 2014). Many researchers have attempted to develop an understanding of what safety culture encompasses. However, the majority of these attempts merely list the various dimensions of safety culture (Reiman & Rollenhagen, 2014) and these dimensions often vary. By simply listing different dimensions of safety culture, the resulting definitions are often an incoherent assortment of various qualities that are difficult to assess. These definitions attempt to include all possible components of safety culture and the

final definition is often unusable (Reiman & Rollenhagen, 2014). Table 3 provides examples of some definitions of organizational culture of safety.

Table 3. Safety Culture Definitions

Authors	Definition of Safety Culture
Amirah, Asma, Muda, & Amin, 2013	A component of the organizational culture that refers to the individuals, jobs and organizational characteristics that affect employees' health and safety
Bentley & Tappin, 2010	The system of shared values and beliefs about health and safety which create behavioural norms which guide health and safety activities in the enterprise
Craig, Das, & Khago, 2010	At group or higher level and reflects on the shared values among all the…organization members [and]…is concerned with formal safety issues with an organization
dos Santos Grecco et al., 2014	Personal attitudes and habits of thought and to the style of organizations
Edwards & Armstrong, 2013	The assembly of underlying assumptions, beliefs, values and attitudes shared by members of an organization, which interact with an organization's structures and systems and the broader contextual setting to result in those external, readily-visible, practices that influence safety
Wu, Lin, & Shiau, 2010	Employees' imaging of safety conditions in the workplace; which images then affect organizational safety activities and safety results

Conceptual models of safety culture. Edward and Armstrong (2013) suggested that idea of safety culture reflects three distinct understandings of it: 1. *Anthropological,* which emphasizes exploring the shared values, beliefs, and assumptions of members of a culture or organization, which leads to safety related outcomes. This conceptualization of safety is unique to safety research as it views the culture of safety in the same way anthropologists view any ethnic culture (i.e., demonstrates the taken-for-granted aspect of culture and its hidden and implicit nature). 2. *Normative,* which focuses on management's actions and polices; and 3. *Pragmatic,* which recognizes that beliefs, attitudes, values, and contextual factors in themselves are insignificant unless they can be tied directly to practices which influence safety. Another framework developed by Guldenmund (2000), suggested that safety culture is composed of three levels: 1. *Basic assumptions* which are the implicit assumptions that guide behavior and tell people how to think about their environment; 2. *Espoused values* are synonymous with attitudes and skills held by employees (i.e., safety measures, personal protective equipment, training, knowledge, etc.); and 3. *Artefacts,* which include the actual safety consequences that are assessed. Morarus and Babut (2012) argued that an effective safety model should include three pillars 1. *Concept of culture*; 2. *Managerial culture*; and 3. *Organizational learning*. When studying organizational culture, the behavioral norms, patterns of values, and human relationships should all be assessed (Garces, 2014). With the exception of these four articles, most safety culture publications are missing an explicit, theoretical model outlining the manner in which safety culture is thought to be embedded in the whole of an organization's practices and system structure. These articles provide the building blocks for such a model, but actual testing of these models in real workplaces is needed.

Dimensions of safety culture. There is a multitude of dimensions that make up safety culture. In order to determine these dimensions most studies asked safety experts to review a list of safety-related attributes (i.e., management concern, peer support, risky behavior, work pressure, safety policy, training, communication, reporting, etc.; Frazier et al., 2013) and to select the most relevant ones. Safety questionnaires are then created based on the dimensions agreed upon by the safety experts and are administered to employees in the industry being studied. A factor analysis is then conducted on these results, which allows researchers to determine what dimensions have statistically significant shared variance with the construct safety culture (Frazier et al., 2013).

A strong safety culture includes: management commitment, communication, safety training, incident reporting, accident investigations, leadership, safety goals and policies, employee engagement, and reward systems (Bentley & Tappin, 2010; Mannan et al., 2013). These dimensions are also closely related to the predictor variables discussed in factor 6 as researchers do not always distinguish between factors that make up the construct of safety culture and factors that predict or facilitate safety culture.

Additionally, Bentley & Tappin (2010) identified five levels of advancement for each aspect of safety culture. These levels of advancement include: 1. *Pathological* is the first level of advancement whereby safety is not considered a priority, 2. *Reactive* is the second level, whereby safety is important but actions are only taken after an incident occurs, 3. *Calculative* has systems in place to manage hazards, 4. *Proactive* has both management and employees anticipating safety problems, and 5. *Generative* is the highest level of advancement and "safety" is just how business is done. These levels of advancement provide means for universally classifying safety culture of an organization. By developing a universal means of classifying mining industries, safety culture can be compared across different organizations and the strategies that are most effective at improving safety culture can be adopted by all organizations.

Conceptualization of Safety Climate. Eight articles are related to the conceptualization of safety climate. Similar to safety culture, there is an abundance of safety climate definitions and models that create conceptual confusion (Zohar, 2010). Additionally, safety climate subcultures can develop when there is a disconnect between management and frontline workers (Walker, 2010).

Origin and definitions of safety climate. Zohar coined the term safety climate in 1980 as a factor that predicts safety behavior and safety related outcomes (Huang, Chen, & Grosch, 2010). Safety climate research actually predates the concept of safety culture; however, after the Chernobyl nuclear explosion, investigators did not feel that safety climate adequately represented the deeply held beliefs, attitudes, and norms that resulted in the disaster as safety climate is associated primarily with employees' perception of organizational safety (Huang, Chen, & Grosch, 2010). Safety climate is often considered to involve the safety perceptions of employees at a given point in time and is dependent on the contextual setting. Theoretically, safety climate should provide a framework to guide safety management practices, and, practically, safety climate is thought to predict safety behavior and safety-related outcomes (Huang, Chen, & Grosch, 2010)

Although the term safety culture is more common within the literature and industry, the concept of safety climate is more likely to actually be measured; that is, safety climate and safety culture are often conflated and confused in applied settings. Indeed, the presence of these two concepts in the literature and

industry has resulted in confusion and difficulty assessing the constructs.

Conceptual models of safety climate. Like safety culture, there are several different models of safety climate. Zohar (2010) developed a pyramid model whereby the bottom layer includes organizational level policies, the middle layer includes group-level priorities of safety vs. productivity, and the top layer includes unsafe acts (Zohar, 2010). Another safety climate model includes Dedobbeleer and Beland's (2013) two factors: 1. Workers' perceptions of management's attitude toward safety practices and foreman behavior and 2. Workers' perception of susceptibility to injuries, risk-taking at work, control over safety, and regular safety meetings.

Safety subcultures. Walker (2010) also found that safety subcultures can develop when there is a disconnect between management and frontline workers. In this case study, the Occupational Health and Safety committee and health insurance companies dictated a specific safety culture that should be followed whereby safety should be a priority with no concern for making a profit. However, management would hire temporary workers and short staff in order to increase profits. This caused the frontline workers to develop their own safety climate subculture in order to get the job done. Frontline workers would work around the official safety procedures when they felt they did not make sense, in order to improve profits.

Psychosocial safety climate. Psychosocial safety climate is a unique construct that deals with the psychological aspects of safety at a group level (Idris, 2012). Psychosocial safety climate differs from safety climate in that safety climate attends to broad safety factors (i.e., physical harm, injuries etc.), while psychosocial safety climate deals with psychological aspects (i.e., bullying, work pressure, stress, etc.). Negative psychosocial safety climate can impact employee performance and result in burnout and poor mental health (Idris et al., 2011). However, positive psychosocial safety climate in a workplace is related to job engagement and improved working conditions (Edwards & Webster, 2012; Idris et al., 2015). (See topic on social-psychological aspects of safety for psychological safety).

Relationship between Safety Culture and Safety Climate. There are three articles that addressed relationships between safety culture and safety climate with three different stances regarding these relationships: 1. Safety culture and safety climate are the same concept, 2. Safety culture and safety climate are distinct concepts, and 3. Safety climate is a subcomponent of safety culture (James et al., 2008).

Safety culture and climate are the same concept. The conceptual confusion regarding concepts of safety culture and climate discussed above has caused some researchers to use the terms safety culture and safety climate interchangeably (James et al., 2008). However, researchers who use these terms interchangeably are only perpetuating the confusion. For example, researchers often assess safety climate when claiming to assess safety culture (Colarossi, 2012; Frazier et al., 2013) resulting in assessment tools that are only assessing the surface features of non-technological aspects of safety. While both safety culture and safety climate deal with the human aspect of safety, there is no literature theoretically supporting the claim that safety culture and safety climate are the same concept.

Safety culture and climate are distinct concepts. Other researchers view safety culture and safety climate as distinct concepts (James et al., 2008) and believe safety climate studies should not be expected

to generalize to the safety culture context (Lu & Yang, 2011). Generally, safety climate is thought to deal with the employee's *perceptions* of the organization's policies and practices (Zohar, 2010) while safety culture is thought to deal with the collective attitudes, values, norms, and behaviors held by all members of the organization. Specifically, climate is often thought to be a property of the *individual* (e.g., a measure of one's opinions of his or her organization's safety) while safety culture includes *shared* expectations and beliefs of the organization (James et al., 2008). Thus, safety culture includes the deeply held beliefs, attitudes, behavior, norms, and values that underlie the organizational culture while safety climate deals with the superficial surface perceptions held by employees.

Additionally, Rollenhagen (2013) argues that, instead of a distinction between safety culture and safety climate, there should be a distinction between safety culture and safety quality. Safety culture and safety quality are separated in order to gain a clearer understanding of the "deeply held beliefs and values" aspect of safety. Rollenhagen (2013) states that many safety culture questionnaires and interviews have limited ability to predict safety, but that a distinction between safety culture and safety quality, could improve this.

Safety climate is a subcomponent of safety culture. Other researchers view safety climate as a subcomponent of safety culture (James et al., 2008). As previously stated, safety climate deals with the surface features and perceptions of safety, while safety culture deals with stable, underlying attitudes, beliefs and behaviors. As such, safety climate may be viewed as a subcomponent of safety culture, wherein safety climate deals with the surface perceptions, while safety culture deals with the underlying assumptions, attitudes, and behaviors. In this case, both concepts are assessing the human aspects of safety, but safety climate deals with the more easily accessible side of safety.

Assessment of Safety Culture and Safety Climate. There are 27 articles related to assessing safety culture and safety climate. Survey questionnaires are the most common means of assessing these concepts; however, limitations to the reliability and validity of these surveys should be addressed. Furthermore, other means of assessing these concepts (i.e., RADAR logic, fuzzy logic sets, etc.) are also used.

Approaches to studying safety culture. According to Guldenmund (2010) there are three approaches to studying safety culture: 1. *Academic* which is often undertaken by researchers attempting to study the past and includes using narrative study, case study, or phenomenological study, 2. *Analytic* uses self-report questionnaires to assess the current safety culture, and 3. *Pragmatic* uses structure, culture, and processes to assess potential future safety culture and is often used within industry.

Safety climate questionnaires. There are an abundance of safety climate assessment tool within the literature, which can make it difficult to compare safety climate scores across organizations. Dimensions that are assessed within these safety climate questionnaires include: management commitment to safety, safety communication, supportive environment, work environment, formal training, priority of safety, and personal priorities and need for safety (Arghami et al., 2013), values, safety systems, communication, and training/coaching/ mentoring (Brondino et al., 2013), management commitment to safety, workers' knowledge and compliance, workers attitudes towards safety, workers participation and commitment to safety, safeness of work environment, emergency preparedness of

organization (Khandan, et al., 2011), safety management system, organization function and resources, safety commitment of top manager, and safety management by immediate supervisors (Tsay, et al., 2012), and management commitment, safety rules and work practices, and responsibility for safety (Hon et al., 2012). These dimensions of safety climate are very similar to the dimension for safety culture (discussed below). This similarity in dimensions is due to confusion about the relationship between these constructs. However, it is generally accepted that safety climate assesses these dimensions at a more superficial level as only perceptions and opinions are assessed (O'Connor et al., 2011). The safety climate questionnaires are usually developed with a specific industry in mind (i.e., aviation, navy, hospital staff, universities, etc.; Olsen, 2010; Tsay, et al., 2012; O'Connor et al., 2011; Gutierrez, 2013), but there are some that were developed specifically for flexible use within various industries (Hon et al., 2012).

Safety culture questionnaires. Compared to safety climate, there are relatively few questionnaire used to assess safety culture. This is because self-report methods are often unable to adequately capture workers' underlying attitudes, beliefs, and behaviors. There is a controversy regarding whether such questionnaires assess safety culture or safety climate. Thus, alternative assessment tools such as documents review and observation were recommended to be used in conjunction with survey questionnaires. Safety culture questionnaires usually include the following dimensions: management concern for safety, personal responsibility for safety, peer support for safety and safety management systems (Frazier et al., 2013) as well as, meaning systems, values, and behavioral expectation (Colarossi, 2012).

Confusion between culture and climate assessment tools. Due to its superficial nature, safety climate is often easier to measure than safety culture. Thus, the majority of assessment tools assess safety climate even when claiming to measure safety culture (Frazier et al., 2013; Collarossi, 2012). Specifically, if only the superficial aspects are assessed (i.e., safety climate) when intending to assess the deeply held norms and assumptions within a workplace (i.e., safety culture), organizations are not obtaining the entire scope of safety leading indicators within their organization and may miss crucial weaknesses that contribute to safety incidents.

Reliability and validity of assessment tools. Several currently used safety assessment tools have either not been tested for reliability and validity (Frazier et al., 2013; Lee et al., 2014; Miyachi et al., 2010) or they have inadequate reliability and validity (de Castro et al., 2013; O'Connor et al., 2011; Pessemier, 2012). Reliability refers to the degree to which a questionnaire will provide similar results when tested on same participants. Validity refers to the degree to which a questionnaire is assessing the constructs it intends to measure. For example, does a safety climate survey truly assessing the safety climate of an organization versus merely assessing the degree to which employees communicate? Many safety culture and climate questionnaires that have been found to have inadequate reliability or validity are still being used by researchers and industries. Thus, these questionnaires may not be measuring what they intend to measure and the safety culture and climate assessment tools may not be adequately predicting the likelihood of injuries and accidents at an organization.

Other assessment tools for safety culture and safety climate. Other methods of assessing safety culture or climate may be useful in conjunction with survey questionnaires in order to counterbalance the

weaknesses of self-report surveys.

Fuzzy sets. Chen and colleagues (2013) developed a fuzzy synthesis evaluation model based on fuzzy logic. This model ranked organizations on whether they are "generally good" or "not good" and in need of improvement. Dos Santos Grecco and colleagues (2014) also make use of fuzzy set theory, whereby employees identify attributes of safety culture and assign degrees of importance to each attribute. The fuzzy set model accounts for the "fuzziness" associated with classifying concepts using human judgement as it uses semantic concepts of imprecise nature and classifies them using mathematical formulas. Additionally, Ruan and colleagues (2012) use fuzzy cognitive maps and belief degrees to assess and classify safety culture. In this case, a fuzzy cognitive map is a mental representation of safety culture attributes, where by the mental landscape between attributes can be used as a means of computing strength of impact between these attributes. Belief degrees allow for a more accurate way of calculating which attributes make up safety culture. For example, belief degrees take into account when one rater believes a certain attribute to be a dimension of safety culture, while another does not, as well as when both raters agree that the attribute is a dimension of safety culture, but one rater holds this belief more strongly than the other (Ruan et al., 2012).

Observation. Freeth and colleagues (2012) found that observation-based assessments provide interesting insights into the safety culture of an organization as it illuminates discrepancies that the safety climate survey could not. The researchers compared survey-based and observation-based assessment methods to assess safety culture. They found that the observation-based responses exhibited reasonably good agreement with the survey-based responses. The survey-based assessments of safety culture exhibited close agreement with the audit scores obtained from most research sites but large differences were found at two of the research sites. Observation field notes illuminated the differences, suggesting the important role qualitative data can play alongside quantitative assessments.

RADAR Logic. Mariscal and colleagues (2012) developed a RADAR (Results, Approach, Deployment, Assessment, and Review) logic model that was able to identify current strengths of the organization, improvements needed, and priority areas to work on. The researchers found this methodology allowed for staff involvement, self-assessment, scoring dimensions of safety, and identifying areas to strengthen the safety culture at the worksite.

Software technology. New technological systems can also aid in assessing safety within organizations. An Artificial Neural Network (ANN) is an information processing system that uses dimensions as inputs and safety climate as an output to develop mathematical models based on human neural biology (Patel & Jha, 2014). Additionally, *Evolute* and *Serpentine 2.0* provide ontology-based answers to linguistic propositions and analyze asymmetries associated with the concept of safety culture (Kantola, Vanharanta, Laukkanen, & Piirto, 2014).

National and ethnic differences in safety culture and climate. There are 10 articles related to individual differences in culture and climate based on ethnicity or nationality. The degree to which safety culture and climate assessment tools transfer across positions, countries, and cultures is of interest to researchers and industries alike.

Translating questionnaires across cultures. Several studies (Bahari & Clarke, 2013; Cigularov, et

al. 2013) have found that safety culture and climate questionnaires do not always transfer across countries, particularly when the questionnaires must be translated from one language to another. Specifically, Bahari and Clarke (2013) found that a safety climate questionnaire developed and validated in the West, did not transfer to an electronic manufacturing company in Malaysia. Additionally, Cigularov and colleagues (2013) found that a safety climate questionnaire developed for Caucasian construction employees did not transfer well to Hispanic, Spanish speaking construction employees. Certain meanings expressed in one language cannot always be translated into the new language, for example, Hispanic Spanish-speaking respondents had difficulties answering several questions that had been translated from English to Spanish (e.g., "my foreman stops work if working conditions are unsafe, even if we have a deadline").

Two questionnaires (Norden-Hagg et al., 2010; Barbaranelli et al., 2015) were successfully translated across countries; however, there were still some differences and a larger number of "not applicable" responses present in the answers, which suggests that respondents may have experienced some confusion regarding these questions. For example, Barbaranelli and colleagues (2015) administered a safety climate questionnaire to American and Italian employees and found that they both had a similar view of the safety climate concept. However, they also found that the safety climate to safety compliance link was twice as strong in the Italian employees. This finding suggests that safety compliance among US workers is less related to the safety climate compared to Italian workers.

Ethno-cultural differences in perception of safety culture and climate. While transferring questionnaires across countries can result in difficulties with interpretation, some research also suggests that employees' perceptions and attitudes of safety culture and safety climate are different among different cultures. For example, Adjukum (2013) found that American and international pilots had different perceptions of the same air base's safety culture (Adjekum, 2013). International pilots perceived that management did not show much concern for safety until there is an accident, whereas American pilots did not share this view (Adjekum, 2013).

Different nationalities have also been found to have different approaches to safety; for example, Havold (2010) discovered that Norwegian and the Netherlands employees have least favorable attitudes towards safety culture. Furthermore, Norway and the Netherlands were found to be the least while Indonesia and the Philippines the most fatalistic countries. Fatalism refers to the idea that employees are powerless to control workplace incidents or stop them from happening.

Organizational subcultures regarding safety. While individuals from different countries can have different perceptions of safety culture and climate, individuals within the same organization can also have different approaches to and understandings of safety depending on their geographic location, specific job, or hierarchal position within the company (Blazsin & Guldenmund, 2015; Craig et al., 2010). These organizational subcultures, also referred to as "cultural islands" (Garces, 2014) or local cultures (Blazsin & Guldenmund, 2015) can impact the perceptions, attitudes, and behaviors of specific groups within the same organization.

Blazsin and Guldenmund (2015) compared the common discourse of three subgroups of employees (field workers, front line supervisors, and managers) within a French oil distribution company

and found that each subgroup had a distinct social reality which caused each to form a unique safety culture. Frontline works perceived the most ambiguity in the company's safety rules, policy, and risks and their discourse represented an "umbrella safety" concept in which safety is perceived as an obstacle or constraint hindering "real work." The discourse of front line supervisors portrayed a "utopian safety" which they perceived to be well-intended and necessary but simultaneously inaccurate and overly ambitious; these workers feel accountable for what happens in the field but did not believe they had control over it which lead to an ambiguous perception of safety culture. Managers had the most rigid discourse regarding safety and perceived the least ambiguity within the company's safety culture; to them, worker safety was equivalent to "project safety". Thus, rather than sharing the same organizational safety culture, each group in this study had its own frame of reference which caused three local safety cultures to develop. Because these groups rarely worked together on site, there was little opportunity for individuals to confront and adjust their different frameworks.

Craig, et al., 2010 also found that individuals who are higher in the organizational hierarchy (e.g., management personnel) tend to have a more favorable and optimistic views of the organization's safety culture compared to frontline workers. Additionally, in a study of offshore vessels, Havold (2010) found that masters, deck and engine officers tended to report more positive safety culture compared to the galley and deck crew. Furthermore, employees from different trades who are working on the same project can also have a different perception of safety. For example, electricians, plumber, pipefitters, and sheet metal workers reported the lowest perceptions of top management's commitment to safety whereas painters reported the highest (Cigularov, et al., 2013). Additionally, laborers reported receiving less support from their supervisors and less resources compared to other tradespeople (Cigularov, et al., 2013).

Facilitators and Barriers of Safety Culture and Safety Climate. There are 28 articles related to facilitators and barriers of safety culture and safety climate. Facilitators useful in developing a strong safety culture have been identified and may aid in decreasing injuries and accidents. These facilitators can be separated based on whether they occur at the organizational level, management level, or employee level; facilitators and barriers are not separated based on whether they refer to safety culture versus safety climate. See Table 4 for facilitators and barriers to safety culture and climate.

Organizational facilitators. Organizational facilitators that can result in an improved safety culture or safety climate include: a strong safety system (Li & Itoh, 2014; Wang & Lin, 2012; Wang & Liu, 2012), safety rules and procedures that make sense (Wang & Lin, 2012; Wang & Liu, 2012; Wu, Lin, & Shiau, 2010), valuing safety as a priority (Boughaba et al., 2014; Henson, 2013; Kelly, 2013), safety incentives and encouragement (Boughaba et al., 2014; Wang & Lin, 2012; Wang & Liu, 2012), safety punishment (Wang & Lin, 2012; Wang & Liu, 2012), learning from incidents (Wamuziri, 2013; Henson, 2013), performance measurement (Wang & Liu, 2012), hiring quality personnel (You, 2010), safe working conditions (Byrd, 2014; Patel & Jha, 2014), safety documentation (Kelly, 2013), risk awareness and knowledge (Grabowski et al., 2010), safety precautions (Ratnasigam et al., 2010), and a strong communication system (Boughaba et al., 2014; Byrd, 2014; Wamuziri, 2013; Wu, Lin, & Shiau, 2010; Fernandez-Muniz, 2012; Garcia-Herrero, 2013; Wang & Liu, 2012; Li & Itoh, 2014; You, 2010), communication is also necessary at the management and employee level; however, it should start at the

organizational level.

Management facilitators. Several facilitators related to management's intention to improve safety culture and climate, including: management commitment to safety (Byrd, 2014; Fernandez-Muniz, 2012; Patel & Jha, 2014; Wang & Lin, 2012; Boughaba et al., 2014; Cooke et al., 2013; Ismail et al., 2010; Wamuziri, 2013; Wang & Liu, 2012; Ratnasigam et al., 2010), visible safety leadership (Henson, 2013; Hystad, et al., 2013; Ismail et al., 2010; Wang & Liu, 2012), managerial training (Wamuziri, 2013), good housekeeping (Biggs, Dingdag, Kirk, Cipolla, 2010), and engaging in toolbox talks with employees (Biggs, Dingdag, Kirk, Cipolla, 2010). Management's safety attitudes and commitment to safety is one of the most important factors associated with a strong safety culture. Havold (2010) found that management attitudes and commitment accounted for almost 55% of the variance in organizational safety.

Employees' facilitators. Finally, facilitators related to employees can also result in a stronger safety culture and climate. These include: employee safety training (Boughaba et al., 2014; Ismail et al., 2010; Wang & Lin, 2012; Wang & Liu, 2012; You, 2010), employee safety engagement (Boughaba et al., 2014; Henson, 2013; Wamuziri, 2013; You, 2010), looking out for fellow co-workers (Garcia-Herrero, 2013; Henson, 2013; Wu, Lin, & Shiau, 2010), careful planning of projects (Biggs, Dingdag, Kirk, Cipolla, 2010; Wu, Lin, & Shiau, 2010; Garcia-Herrero, 2013), using safe work method statements (Biggs, Dingdag, Kirk, Cipolla, 2010; Wamuziri, 2013), using proper personal protective equipment (Wamuziri, 2013), reporting incidents (Grabowski et al., 2010; Wamuziri, 2013; You, 2010), and engaging in teamwork (Grabowski et al., 2010). Employees should have adequate safety awareness and safety attitudes as well as the safety knowledge needed to complete their job, and willingly engage in safety meetings and training (Wang & Liu, 2012).

Barriers to safety culture and climate. Barriers to safety culture and climate can make it more difficult to build a strong safety culture within an organization. Some of these barriers include: blaming employees for accidents (Wamuziri, 2013; Wadick, 2010), high work pressure (Fernandez-Muniz, 2012), high stress (Garcia-Herrero, 2013), low education and literacy of employees (Fang & Wu, 2013; Wadick, 2010), rules and regulations that are unclear (Fang & Wu, 2013; Wadick, 2010), high cost for training and personal protective equipment (Wadick, 2010), little priority on off-the-job training (Fang & Wu, 2013; Wadick, 2010), little priority on training supervisors in people skills (Wadick, 2010), employees who are more concerned with wages and production than safety (Martykaa & Lebeckia, 2014), and the persistence of unique subcultures (Blazsin & Guldenmund, 2015).

However, this literature is controversial as some facilitators are also cited as barriers to safety culture and climate. For example, punishment for unsafe behavior has been found to facilitate (Wang & Lin, 2012) and hinder the development of a strong safety culture (Wadick, 2010). Wadick (2010) argues that blaming employees for accidents leads to mistrust and under-reporting of incidents. Consequently, it is more beneficial to reward employees for safe behavior than to punish employees for unsafe behavior (Wadick, 2010). Similarly, Boughaba and colleagues (2014) view incentives as beneficial to developing a strong safety culture, while Ismail and colleagues (2012) found monetary rewards to be less beneficial than previously thought. Ismail and colleagues (2012) recommend using praise and recognition instead of monetary rewards, because using monetary rewards is associated with under-reporting of incidents.

Additionally, accountability has been found to be negatively related to safety climate, which appears counterintuitive (Kelly, 2013). However, Kelly (2013) argues that employees who are accountable for their own safety actions are more likely to notice when others behave in an unsafe manner which results in a heightened sensitivity of a negative aspects of safety climate.

Table 4. Facilitators and Barriers of Safety Culture and Climate

Facilitators of safety culture/climate	**Barriers of safety culture/climate**
Safety training	No off-the-job training and high cost for training
Managerial training	Supervisors receive little training on human-relation skills
Safety rules and procedures	Rules and regulations are unclear
Safety encouragement/incentives	Monetary rewards
Safety is a priority	Employees more concerned with wages than safety
Using proper PPE	High cost for PPE
Safety punishment	Punishment for unsafe behavior
Manager's commitment to safety	Blaming employees for accidents
Communication	Stress
Visible safety leadership	High accountability
Employee involvement	Low education level
Safety systems	Low literacy level
Looking out for fellow co-workers	Work pressure
Careful planning of projects	Persistence of unique subcultures
Learning from incidents	
Performance measurement	
Encouraging reporting	
Using safe work method statements	
Hiring quality personnel	
Safe working conditions	
Good housekeeping	
Meaningful toolbox talks	
Safety documentation	
Risk awareness	
Safety precautions	
Teamwork	

Outcomes Associated with Safety Culture and Safety Climate. There are 28 articles related to outcomes associated with safety culture and safety climate.

Safety culture, injuries, and accidents. Due to the fact that safety culture is less superficial and changeable than safety climate, it may be a better predictor of injuries and accidents. While fewer studies have been conducted on the outcomes of safety culture, two out of three studies have demonstrated relationships between improved safety culture and decreased injuries and accidents (Boughaba, Hassane, & Roukia, 2014; Wang & Lin, 2012). Furthermore, it was also discovered that the more mature and experienced a company is, the better their safety culture tends to be.

Safety climate, injuries, and accidents: Contradictory evidence. The findings from other studies have been less consistent. Out of 15 studies included in this review, six have failed to find a relationship between a strong safety climate and decreased injuries and accidents (Beus et al., 2010; Cheyne, et al., 2013; Fugas, Silva, & Melia, 2012; Kufner & Plybon, 2012; Lingard, Cooke, & Blismas, 2010; Smith &

DeJoy, 2014). One study even found that safety climate was related to a higher frequency of injuries (Smith & DeJoy, 2014). However, it is important to remember that employees do not always report all injuries or accidents which makes comparison difficult and could explain why no relationship is found. Smith and DeJoy (2014) suggest that one reason why safety climate could be related to *higher* injuries and accidents is due to "reverse causation." Reverse causation occurs when an individual who has experienced a high number of injuries becomes more safety conscious following these accidents and, consequently, perceives the safety climate of their organization as improved.

Although the remaining 8 studies found safety climate to be related to decreased injuries and accidents (Hon, Chan, & Yam, 2014), they tended to have methodological weaknesses that mitigated the findings. Two studies found a small correlation that was moderated by the type of research design (Clarke, 2006) and employees' general health (Clarke, 2010). Another investigation found that safety climate was related to injuries but that physical work environment was more important for the reduction of injuries than safety climate (Bjerkan, 2010). Additionally, the relationship between safety climate and safety behaviors was fully mediated by other cognitive and social variables (e.g., safety norms, attitudes, control, etc.; Fugas, Silva, & Melia, 2012). Finally, safety climate was found to be related to lower accident rates, improved job satisfaction, and increased compliance for experienced employees only (Gyekye & Salminen, 2010). In total, out of 15 studies, only four found a direct link between safety climate and decreased injuries and accidents (Braunger et al., 2013; Cooper & Phillips, 2013; Tholen et al., 2013; Hon, Chan, & Yam, 2014).

Other beneficial outcomes of strong safety culture. The decreased injuries and accidents associated with strong safety culture lead to additional benefits such as improved overall health of employees, high production capacity, and better control (Braunger et al., 2013). Reduced occupational accidents were also associated with improved safety attitudes, acceptance of safety rules and regulations, less work pressure, and a more reasonable production schedule (Hon, Jimmie, & Chan, 2014).

Safety Culture and Climate Interventions. Seven articles discussed safety culture interventions, followed by general guidelines for improving safety culture and safety climate within organizations.

Specific safety culture intervention programs. There were two safety culture intervention programs: a *Lean Continuous Improvement Process (LCIP)* intervention implemented in nuclear plants (Wells, 2010) and *After Action Reviews* (Allen, Baran, & Scott, 2010). The LICP focused on continuously improving the safety of the organization by reducing process waste and operating costs. Among nuclear plants where the LCIP was implemented, two safety culture indicators (i.e., material unavailability and schedule errors) were related to increased productivity, decreased cost, and increased quality.

After Actions Reviews intervention refer to a process in which employees discuss their job after completion of different tasks to determine how these tasks went and whether there are ways to improve them (Allen, Baran, & Scott, 2010). These researchers found that partaking in after action reviews more frequently is related to a strong group and organizational level safety climate and well as improved safety group norms. However, the relationship was partially dependent how busy the company was at the time of the study. Bonilla (2013) also found after action reviews to be related to a stronger safety climate.

General intervention guidelines. The included literature also revealed general guidelines that

companies may utilize to improve safety culture and safety climate most effectively. These guidelines include the following: (1) emphasize an upper management's commitment to safety, (2) reward safe behavior, but use gift cards instead of cash, (3) emphasize that injuries are preventable, (4) engage every stakeholder in the intervention, (5) have systems in place for reporting and reviewing incidents, (6) aid employees in developing collaboration skills, and (7) keep employees updated on any changes within the organization (Mengolini & Debarberis, 2012; Naevestad, 2010; Zou, 2010). Safety incentive programs aimed at reducing incidents may unintentionally reduce the reporting of incidents as employees strive to receive their reward. However, rewarding both lagging *and* leading indicators may encourage employees to continue behaving safely (Thomas, 2012). In order to improve the safety culture within an organization, it is important that employees see management behaving safely so they can model their behavior. Additionally, when trying to change a behavior, frequent and immediate feedback is necessary (Zou, 2010). (See also topic on incentive based programs for more information).

Intervention guidelines for management. Thomas (2012) suggested specific guidelines that management and administrative personnel can follow in order to optimize their safety culture and safety climate interventions. First, management should not place profitability before safety as the employees will internalize the message that production comes before safety. Second, management staff should not demand anything of their employees that they would not do themselves. For example, if the reporting system in place is time-consuming and tedious, management should not expect their employees to willingly report incidents if they would not be willing to do so themselves. Finally, when attempting to change behavior, rewards and reinforcements for safe behavior should be used for a minimum of 21 days as this is the time needed to break an old and form a new habit

Discussion

As this chapter demonstrates, there has been considerable research on safety culture and safety climate within industry and academia. Industry safety professionals are looking for these phenomena as powerful leading indicators/factors to prevent accidents and injuries. However, the validity and utility of the current findings is limited by a perpetual conflation between safety culture and climate constructs, which substantially limits the values of these concepts. Thus, a clear conceptual understanding of these non-technological organizational phenomena is crucial for their successful application. Qualitative assessment tools need to be used in conjunction with survey questionnaires to more accurately measure safety culture and safety climate as well as adequately prevent and predict injuries and accidents within organizations. Ethno-cultural dissimilarities among nations where companies function and companies' differences in organizational structure and culture should be taken into account when administering questionnaires and tailoring safety training. Finally, mechanisms of developments of safety culture and it influence on safety performance is only starting to emerge and should be continued.

Gaps in the Literature. Previous attempts to conceptualize safety culture and safety climate often merely list the dimensions associated with each construct. Not only does this created confusion within the literature when distinguishing between these constructs and determining their predictive factors, it also makes it difficult to form a single, coherent definition for each construct. Many safety culture publications are not using conceptual models that explains the relationship between safety culture and safety outcomes. Furthermore, some researchers who did provide such models have not tested them within a real industrial setting. A system thinking is needed in order to conceptualize both safety culture and safety management as two complementary factors for safety improvement (Reiman & Rollenhagen, 2010).

Additionally, further research is needed to determine the mechanisms of relationships between safety culture and safety climate and of these phenomena with safety behavior and outcomes. As previously stated, it can be difficult to distinguish safety culture and climate constructs from their predictive factors as they are often treated as one and the same within the literature. Similarly, it is also difficult to distinguish safety culture facilitators and barriers from safety climate facilitators and barriers as many researchers inaccurately use the terms interchangeably. Determining the relationship between these constructs of these constructs with safety performance could resolve these issues.

There is also little research ranking the effectiveness of various facilitators and barriers to create a strong safety culture or climate. Knowing which facilitators are the most useful is necessary in order to effectively build a strong safety culture.

The vast majority of assessment tools developed in the literature are quantitative self-report questionnaires; however, in order to more adequately assess safety culture and climate, there is a need for qualitative assessment tools such as interviews, focus groups, and observation , analysis of documents and communication protocols. Furthermore, when developing survey questionnaires, most studies assess the reliability of the questionnaire but few assess the validity. Specifically, predictive validity is necessary to determine whether the safety culture/climate assessment tool is actually related to injuries and accidents in the workplace. Furthermore, many questionnaires are still in use even when some questions, or even entire dimensions, have failed to demonstrate adequate reliability and validity. These questionnaires should be revised before use.

There are also inconsistencies in the literature regarding what factors facilitate and hinder safety culture and climate. For example, punishing employees for unsafe behavior and providing monetary incentives for safe behavior have each been found to both facilitate and hinder safety culture. There is some evidence that punishing employees for unsafe behavior leads to increased safe behavior as employees know anything less is not tolerated (Wang & Lin, 2012). However, punishing employees may also lead to mistrust and fear of losing one's job over an accidental unsafe behavior; this mistrust could also lead to under-reporting of incidents (Wadick, 2010). Additionally, while some studies suggest that providing monetary incentives increases safety behavior (Fernandez-Muniz, et al., 2012), other studies suggest that monetary incentives may not be as effective as originally thought (Ismail et al. 2012).

Finally, the majority of the current research on safety culture and safety climate was conducted in industries other than mining: nuclear, construction, aviation; although there are similarities between these

industries and mining, future research should target the mining industry specifically.

Recommendations. This scoping review of existing safety science research suggests that safety specialists and trainers may utilize the knowledge collected from psychological research to develop more effective and accurate means of assessing safety culture and climate in the workplace. Based on the current scoping review, future efforts may include an integration of the following recommendations:

- **Critically reflect on the understanding of safety culture and climate in the context of a particular company or site.** When using any tool or equipment, one must understand its design and mechanism to use it efficiently; similarly, safety experts must understand social-organizational phenomena in order to use them efficiently. Without clear understanding of the nature of safety culture and its difference from climate, the efficiency of measuring and using it as a leading indicator may be limited.
- **Critically assess safety culture or climate measures before using them.** Industry members should strive to only use surveys and measurement tools that have been validated among other similar mining companies. Using the most accurate measures will result in data that is more meaningful and useful. If valid and reliable tools are not available, mining industries in similar contexts may be better off to pool resources and develop their own assessment of safety culture than to continually use invalid or unreliable measures.
- **Develop a standardized means of classifying safety culture that is comparable across similar industries.** Mining companies should determine what level of advancement (i.e., pathological, reactive, calculative, proactive, or generative; Bentley & Tappin, 2010) they are at for each safety culture aspect in order to determine the safety culture at their specific organization. By developing a universal means of classifying mining companies, safety culture can be compared across different organizations and the strategies that are most effective at improving safety culture can be adopted by these organizations. Additionally, assessment questionnaires should each assess the same safety culture/climate aspects in order to allow organizations to compare their scores across one another and to ensure each organization is adequately capturing the safety culture/climate at their organization.
- **Use qualitative assessment tools in addition to questionnaires to assess safety culture.** O'Connor and colleagues (2011) suggest that long and complex surveys should not be the only method used to assess safety climate. Instead both quantitative and qualitative methods should be used. Observation, interviews, analysis of documents and communications should be paired with survey questionnaires in order to obtain a better understanding of an organization's safety climate and safety culture.
- **When using questionnaires to assess safety culture and climate, use questionnaires developed specifically for the mining context and Canadian populations.** When translating questionnaires across languages, it is important to be careful of the wording of the question to ensure that the desired meaning translates and makes sense. When using safety culture and safety climate questionnaires, industry members should be careful to ensure that the specific questionnaire was meant for their population (i.e., avoid using a questionnaire designed for a mine in China when it will be administered to Canadian populations), as questionnaires designed for other cultures do not

always assess the core of the current culture. For example, Frazier and colleagues (2013) have developed a safety culture questionnaire that is aimed at a variety of industries (of which mining was one industry) across all continents and this questionnaire may provide a broad overview of safety culture at Canadian mines. However, in order to obtain the most accurate representation of the Saskatchewan mining industry, tailored survey questionnaires may need to be developed.

- **Assessment tools and training should be tailored to employees' needs**. Immigrants and individuals from other ethno-cultural backgrounds within the Saskatchewan mining industry should also complete questionnaires and training that are tailored specifically to their needs and view of safety culture/climate. Specific subcultures within the organization may also need tailored assessment and training. For example, managers should be trained in leadership skills, how to promote safety behavior to their employees, and how to recognize when an employee may be unable to work safely (i.e., due to psychosocial factors).
- **Organizations must work to remove the disconnect between management and frontline workers' perceptions of safety culture and climate.** Compared to frontline workers, management tends to have a more optimistic and rigid view of the safety culture at their organization; more between-group communication and collaboration will allow differences in safety cultures to be confronted and re-adjusted.
- **Ensure all trades receive the same resources**. One barrier to a strong safety culture/climate is the lack of training and proper personal protective equipment. Thus, every individual from every trade must receive the training and resources they need. Particular attention should be given to contract workers who may receive separate training. If possible, having employees and contract workers receive the same level of training tailored for their specific task will improve the safety knowledge and ability of these workers.
- **Understand and promote facilitators of a strong safety culture**. Management should promote improvements in areas that have been found to facilitate a stronger safety culture and climate (i.e., management commitment to safety, safety leadership, communication, safety training, careful planning of job tasks, valuing safety, learning from incidents, easy, anonymous reporting, etc.).
- **Eliminate barriers to a strong safety culture**. Management should attempt to remove as many barriers to a strong safety culture and climate as possible (i.e., blaming employees for accidents, high stress environments, work pressure, placing production before safety, unclear rules and regulations, etc.). A proactive participation of ground-level employees in this process is crucial for its success
- **Use praise and recognition to increased safe behavior.** Monetary rewards may not be as effective at reducing injuries and accidents as previously thought and they may also increase under-reporting. As such, providing prompt positive feedback, praise, and public recognition for safe behaviors may be more effective at improving safety. Management and frontline workers should all be taught to provide praise and feedback when witnessing safe behavior. It may be difficult to stop providing more experienced employees with monetary incentives as they have come to expect this reward and may dislike the change. However, monetary incentives can still be provided, but praise and recognition should become the main reward for safe behavior. When trying to change behavior,

feedback and praise should be promptly provided for at least 21 days in order to form a habit.

- **Use after-action reviews after unusual or high risk tasks.** After-action reviews involve discussing the job after it has been completed and determining ways it could be improved or completed more safely. The higher the frequency of after-action reviews, the stronger the safety culture and safety group norms.

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