Work 76 (2023) 549–560
DOI:10.3233/WOR-220214
IOS Press

Exploring safety culture research in the construction industry

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Received 14 April 2022
Accepted 10 January 2023

Abstract.
BACKGROUND: Despite numerous regulatory initiatives to improve health and safety in the construction industry, it still ranks as one of the most accident-prone industries worldwide. A dedicated focus on safety culture has been suggested as a complement to laws, regulations and management systems.
OBJECTIVE: This article explores safety culture research conducted in the construction industry, with the aim to provide insight into the specific themes that tend to be in focus as well as what theoretical and methodological approaches that tend to be favored.
METHODS: Searches in scientific databases were conducted twice. In a first attempt, searches resulted in 54 hits but only two articles fit the scope of the study. A revision of the search phrase resulted in 124 hits. Ultimately, 17 articles fit the scope of the study and were included. The content of the articles was analyzed and sorted thematically.
RESULTS: The results show that four themes are prevalent in the existing literature: 1) unique challenges entail a need for situated applications, 2) models developed to operationalize safety culture, 3) measuring safety culture, and 4) safety management and leadership as key factors.
CONCLUSION: Although research focusing on the construction industry has come to favor certain study designs and definitions of safety culture, further research may be enriched by broadening the theoretical and methodological perspectives. Specifically, researchers should conduct more in-depth qualitative studies that take the complexity of the industry into account, including the interpersonal relations between the actors involved.

Keywords: Construction work, occupational health and safety, safety management

1. Introduction

Construction often ranks as one of the most risk and accident-prone industries, regardless of country [1]. Although regulatory initiatives often target the industry in question, and despite the frequent use of safety management systems and related practices, accidents continue to plague construction-related work [1–3]. One solution that has been proposed to combat this problem is a dedicated focus on *cultural issues* in relation to safety, as a complement to the traditional focus on structure and processes, e.g., in the form of regulations and safety management [4]. For example, in 2019, the employers' association Swedish Construction Federation opened a safety park in Stockholm, Sweden. The park would serve as a training facility where construction companies from all over the country could send their personnel to train in safety-related matters. In one of the brochures that the employers' association produced to describe the park, it is stated that: "The goal [of the safety park] is to create a deeper understanding of what kind of attitudes and behaviors that are needed to create a safety culture with fewer accidents and incidents." This example is illustrative of a development in the modern construction industry where a dedicated focus on safety culture, both in theory and in practice, has been heralded as a solution to the industry's poor safety record.

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Still, despite decades of research focusing on various industry sectors, there is no apparent consensus on what safety culture actually entails or what methods should be used when studying the phenomenon. An exception is the notion that safety culture, in some way or another, is connected to a broader organizational culture. Several researchers have argued that safety culture should not be viewed in isolation but rather as a subset within a broader cultural context [4–6].

With this in mind, the purpose of this article is to explore safety culture research conducted in the international construction industry. The goal is to provide insight into the specific themes that tend to be in focus when studying safety culture in this particular industry context, as well as what theoretical and methodological approaches that tend to be favored by researchers. Given the importance that is placed on safety culture as a complement to traditional safety management practices, it is vital to highlight common trends and themes in the existing literature as a basis for further theoretical and methodological development.

The paper is structured as follows. First, a description of the methodology used in this review is provided. After that, the results section is presented focusing on safety culture research conducted in the construction industry specifically. Finally, results are discussed and conclusions are drawn. Also, several suggestions are provided for further research on safety culture in the construction industry.

2. Materials and methods

The review process started by the authors developing an outline of a strategy for how to conduct the review. This step included how to gather and compare data from the articles, decisions on search phrases and search engines as well as inclusion and exclusion criteria. Below, the process is described as it progressed during the data selection, the data collection and the data analysis.

A search phrase was developed aimed to capture articles that focus on safety culture directly as well as indirectly in relation to the construction industry. The search phrase was: (“health and safety” OR “safety and health” OR “occupational health and safety” OR “occupational safety and health” OR safety) AND (“construction industr *” OR “construction work”) AND (train * OR learn *) AND “safety culture”. The search was performed in the databases Scopus and Web of Science core collection in January 2020 and generated 35 and 19 hits, respectively. The selection of articles was limited to articles and reviews written in English. However, when the articles were read by the five authors, it was concluded that only two fit the scope of the study. The main reason for excluding certain articles was that they did not address safety culture sufficiently (e.g., conceptual vagueness in the sense of not addressing safety culture specifically). The primary inclusion criterium was that the studies had to address safety culture analytically in the form of either empirical findings and/or theoretical analysis.

A further and broader search to identify articles focusing on safety culture in the construction industry was therefore conducted in Web of Science in February 2020 using only the keywords “safety culture” and “construction industry”. It generated 124 hits. Except for articles that overlapped with the first sample, the abstracts of the new texts were read, of which 21 met the inclusion criteria of addressing safety culture in depth and were relevant to the purpose of the study. In the next step, articles were read in their entirety. The articles were divided between the five members of the research group who read and summarized them individually according to their general content, perspective on safety culture and methodological approach. To reduce the risk of bias in the selection of articles, the members of the research group had several meetings where the articles, both the included and excluded ones, were discussed. The summarized material was then compiled in a joint document for further analysis in that same document. In this process six more articles were excluded for the same reasons as during the first literature search, i.e., safety culture was not sufficiently addressed, and 17 were ultimately selected for further analysis, comprising both empirical studies and literature reviews that contained in-depth analyses of safety culture (Fig. 1).

The analysis process of the material was inspired by conventional content analysis [7] to gain a deeper understanding of how safety culture is understood and applied in research conducted in the construction industry. Starting from the joint document, the five authors discussed similarities and differences in the approach to safety culture in the different articles. Although all articles have safety culture in the construction industry as their analytical or empirical focus, they differ in their research focus. While some articles study ways to measure safety culture, others for example investigate the role of management. Pat-

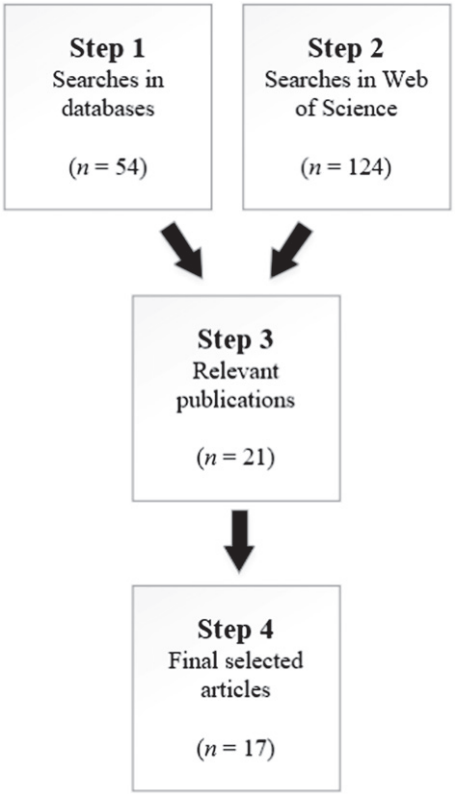

Fig. 1. Article selection process.

terns of similarities (i.e. themes) also emerged. For example, four articles reported on models of safety culture and in our findings section we analyze how different models have been used and developed over time. Another pattern, investigated in seven articles, was the role of management for safety culture. Here, we divided the articles based on if it was management systems and safety programs or if it was leadership that was in focus.

3. Results: Safety culture research in the construction industry

Our analysis revealed four prominent themes in literature, which are accounted for in this section. The first theme *Unique challenges entail a need for situated applications* highlights the importance of taking the complex context of construction into account when working with safety culture. The second theme, *Models developed to operationalize safety culture* reports on commonly used safety culture models and describe how they are developed over time. The third theme, *Measuring safety culture,* highlights how the concept can be measured and reports on reasons for doing this. The fourth theme, *Safety management and leadership as key factors* accounts for management and safety programs as well as the role of leadership in relation to safety culture. Overall, a given article may also have one or more of these themes present (see Table 1 for the full selection of articles).

3.1. Unique challenges entail a need for situated applications

We identified six papers that place particular emphasis on the importance of considering the unique contextual aspects of the construction industry when analyzing safety culture. According to Deepak and Gangadhar [8] there is still no precise explanation of the term safety culture. However, some definitions have been suggested. For example, Choudhry et al. [9] suggest the following definition for safety culture as it is manifested in the construction industry specifically:

"... the product of individuals and group behaviors, attitudes, norms and values, perceptions and thoughts that determine the commitment to, and style and proficiency of, and organization's system and how its personnel act in terms of the company's ongoing safety performance within construction site environments" [p. 211].

Even though researchers have suggested partly different definitions, Deepak and Gangadhar [8] argue that there is consensus regarding the matter of safety culture being a proactive strategy for handling safety-related issues in practice.

Four studies focus specifically on the structure, processes and the overall context that characterize the construction industry. For example, Fang and Wu [10] point out that the dynamics that evolve between developers, contractors and subcontractors are unique for the construction industry. Each party contribute with their own safety culture and as well contribute to the overarching, potential safety culture at the worksite as a whole. Another unique condition is the production process in the construction industry, both in terms of the actual construction process itself but also in terms of logistics, that often occur simultaneously and must be coordinated under time pressure. Among other things, this means that the behavior of the employees cannot be predicted in the same manner as in other industry sectors.

Waddick [11] also place emphasis on the importance of considering the complexity inherent in the construction industry. Via an ethnographic study con-

Table 1
Articles included in the review

Authors (year)	Title	Topic	Method	Theme
Biggs et al. (2013)	Safety leaders' perceptions of safety culture in a large Australasian construction organization	How safety culture is perceived by safety leaders in an Australian contractor firm	Survey and interviews	Safety management and leadership as key factors
Chen & Jin (2013)	Multilevel safety culture and climate survey for assessing new safety program	Evaluation of the importance of safety programs for safety culture on construction sites	Survey	Measuring safety culture, Safety management and leadership as key factors
Choudhry et al. (2007a)	Developing a model of construction safety culture	Development of a safety culture model for the construction industry	Literature review	Unique challenges entail a need for situated applications, Models developed to operationalize safety culture
Choudhry et al. (2007b)	The nature of safety culture: A survey of the state-of-the-art	Development of a state of the art of safety culture research in the construction industry	Literature review	Models developed to operationalize safety culture
Deepak & Gangadhar (2019)	Review of concepts and trends in safety culture research of construction industry	Development of state of the art of safety culture research in the construction industry	Literature review	Unique challenges entail a need for situated applications, Measuring safety culture
Dingsdag et al. (2008)	Understanding and defining OH&S competency for construction site position: Worker perceptions	An analysis of attitudes and perceptions in Australian contractor firms that influence competency, skills and behavior	Survey	Safety management and leadership as key factors
Fang & Wu (2013)	Development of a Safety Culture Interaction (SCI) model for construction projects	Development of a safety culture model for the construction industry with a focus on both contractors and subcontractors	Survey	Unique challenges entail a need for situated applications, Models developed to operationalize safety culture, Measuring safety culture
Feng & Trinh (2019)	Developing resilient safety culture for construction projects	An analysis of safety culture in relation to the concept of organizational resilience	Survey	Models developed to operationalize safety culture
Feng et al. (2014)	Exploring the interactive effects of safety investments, safety culture and project hazard on safety performance: An empirical analysis	An analysis of the connections between safety investment, safety culture and safety performance in construction projects in Singapore	Interviews, survey, archival records	Safety management and leadership as key factors

Gilkey at al. (2012)	Comparative analysis of safety culture perceptions among HomeSafe managers and workers in residential construction	An analysis of safety culture and risk perception in a safety program in the US construction industry	Survey	Safety management and leadership as key factors
Lee (2019)	Safety culture evaluation model at construction site	Development of a safety culture model for the construction industry	Interviews and survey	Measuring safety culture
Mohamed & Chinda (2011)	System dynamics modelling of construction safety culture	An analysis of the interaction between organizational factors and safety culture on construction sites in Thailand	System dynamics modelling	Unique challenges entail a need for situated applications
Molenaar et al. (2009)	Framework for measuring corporate safety culture and its impact on construction safety performance	An analysis of the relation between safety culture and safety performance in construction projects in the United States	Survey	Unique challenges entail a need for situated applications
Teo & Feng (2009)	The role of safety climate in predicting safety culture on construction sites	An analysis of the relation between safety culture and safety climate on construction sites in Singapore	Survey	Measuring safety culture
Waddick (2010)	Safety culture among subcontractors in the domestic housing industry	Development of a safety culture model focusing on subcontractors in the Australian construction industry	Interviews, observations	Unique challenges entail a need for situated applications
Wu et al. (2016)	How safety leadership works among owners, contractors and subcontractors in construction projects	An analysis of safety leadership on construction sites in China	Survey	Safety management and leadership as key factors
Zou (2011)	Fostering a strong construction safety culture	Development of a safety culture model for the construction industry	Case studies	Safety management and leadership as key factors

sisting of participant observations, interviews, and document analysis over a nine-year-period in the Australian construction industry, the author suggests that seven aspects can be included in analyses of safety culture: 1. the temporary workplace, 2. working methods involving heavy manual labor, 3. contractor chains, 4. the male-dominated workforce and workplace culture, 5. equipment and materials, 6. workplace training or lack thereof, and 7. health and safety training or lack thereof.

Mohamed and Chinda [12] take a similar holistic perspective focusing on the potential impact that so-called 'safety culture enablers' have on organizational safety goals. The authors underline five specific enablers as particularly important to consider in relation to safety culture: leadership, co-workers, partners and resources, policy and strategies, and processes. In line with this, Molenaar et al. [13] mention five latent variables that can be used to describe safety culture:

1. The safety commitment of a company.
2. The incentives that are offered to individuals for safety performance.
3. Subcontractors' involvement in culturally related issues.
4. Accountability and devotion to safety.
5. Safety responsibility and substandard safety behavior.

3.2. Models developed to operationalize safety culture

Four of the included articles focus on the importance of applying specific theoretical models and perspectives when analyzing safety culture. Fang and Wu [10] make reference to two safety culture models as being especially appropriate in this regard: Geller's [14] Total Safety Culture Model and Cooper's [15] Reciprocal Safety Culture Model. Fang and Wu describe that Geller identifies three dimensions of safety culture in the form of environmental factors, personal factors, and behavioral factors. These three factors interact with each other and comprise a triangle that Geller calls the safety triad. Fang and Wu argue that this safety triad illustrates the composition of safety culture but not the specific interactive relationships that exist between the different dimensions. In Cooper's model, on the other hand, environmental factors are expanded to also include safety management systems, i.e., the model points towards the interaction and the reciprocal relationships between psychological factors, observable behaviors, and organizational functions. Fang and Wu conclude that the model can be used as a starting point for benchmarking different organizations.

Choudhry et al. [9] develop Cooper's [15] model so that it can function as a practical tool when investigating the construction industry. An advantage of the developed model is, according to the authors, that it facilitates a triangulation regarding measurement tools. The situational factors, i.e., policy, management systems, division of roles and responsibilities, etc., can be mapped via surveys where safety climate is in focus. Safety behavior, on the other hand, can systematically be studied through checklists and observational protocols within the confines of a behaviorally based safety program.

Based on these perspectives, and the above-mentioned models with reference to Geller [14] and Cooper [15], Fang and Wu [10] form a model of their own – Safety Culture Interaction Model – in which they place actors that are commonly involved in the process (i.e., developers, contractors, and subcontractors) and try to capture the dynamics between them. The starting point is an empirical investigation of two construction projects in Singapore and, in line with what is mentioned above, Fang and Wu argue that safety culture is contextually determined and consequently that one ought to talk about project-specific safety culture. The model furthermore includes a differentiation between management and worker safety culture and that these have fundamentally different conditions. A result from the study is that there are differences between how managers and workers view safety, in large part due to the 'playing field' for managers being much more complex with at least three parties having to coordinate their activates under time pressure. At the same time, the authors argue that the managers' safety behaviors have an impact on how workers ultimately behave with regards to safety. A conclusion from the study is that to understand safety culture, one needs to understand the culture among managers specifically and implement corrective measures on that level. This may ultimately also have positive effects in relation to the worksite itself, i.e., among the workers [10].

Feng and Trinh [16] take a starting point in a perspective of safety culture advocated by, for example, Choudhry et al. [17], i.e., that it is important to consider individual psychological factors, as well as behavioral and situational/contextual aspects. Three different methods can consequently be triangulated

when investigating safety culture to highlight what can be seen as three separate, but interwoven, dimensions of safety culture. However, the authors add another theoretical term to the discussion of safety culture, namely resilience. Resilient organizations are characterized by the capacity to anticipate, monitor, and address safety-related risks effectively, as well as continually learn from incidents occurring. Feng and Trinh suggest that previous research regarding safety culture can be combined with theoretical perspectives focusing on resilient organizations. This would include a focus on psychological resilience on an individual as well as group level, behavioral resilience in terms of competence and behavioral patterns among employees regarding workplace risk, and contextual resilience regarding the organization's efforts to prevent safety-related risks. In line with this, Feng and Trinh define resilient safety culture as "an organization's psychological, behavioral, and contextual capabilities to anticipate, monitor, respond, and learn in order to manage safety risks and create an ultrasafe organization" (1). They furthermore apply this theoretical perspective in an empirical study of the Vietnamese construction industry through a survey with 115 respondents, all active as project managers. The results show that construction companies that actively focus on minimizing safety-related risks affect contextual and behavioral resilience; that actively focusing on correcting safety-related issues in the workplace affects the psychological resilience; and that a focus on work organization affects contextual resilience – all in a positive manner.

3.3. Measuring safety culture

Five articles address matters concerning the measurability of safety culture in empirical studies. According to the Deepak and Gangadhar [8], it is vital to have correct measurements and measuring instruments when evaluating safety culture. Lee [18] furthermore argues that safety culture is something that can be objectively measured through quantitative methods, e.g., through analysis of construction workers' perceptions regarding safety in the workplace. A starting point in the theoretical approach is also that safety culture can be actively created and that it is important that individuals in a managerial position within construction companies are active in the development work (see below, "Safety management and leadership as key factors"). The level of safety culture is often evaluated through quantitative questionnaires based on the above-mentioned factors. Out of the multitude of instruments, Safety Climate Assessment Tool (S-CAT) is according to Deepak and Gangadhar one of the best, i.e., an evaluation tool that is specifically designed for the construction industry and that focuses on safety climate rather than safety culture per se.

According to Fang and Wu [10] there has been a long-standing debate regarding the differences between, and definitions of, safety culture and safety climate, respectively. Despite disagreements regarding choice of term overall, safety climate is often viewed as a measurable reflection or aspect of safety culture – an aspect that is commonly measured through a questionnaire or through structured interviews. Chen and Jin [19] take a similar position and mention that measurements of safety climate can serve as a basis for evaluations of safety culture. Safety climate can, consequently, be defined as workers' perceptions or understanding of the role that safety plays in the workplace and workers' attitudes towards safety-related issues. According to Teo and Feng [20] safety climate affects three dimensions of safety culture, i.e., personal/psychological, behavioral, and situational aspects, respectively. Several project-specific factors such as the duration of a project, the size of the project and number of subcontractors, can also affect the relationship between safety climate and safety culture. Teo and Feng draw a conclusion that an assessment of safety climate can provide a reliable picture of an organization's overall safety culture. Fang and Wu, however, argue that measurements of safety climate can only give insight to some of the parts that could be said to constitute safety culture, while at the same time being one of the few ways to provide a picture of safety culture (i.e., through quantitative measurements).

3.4. Safety management and leadership as key factors

A prominent focus area, addressed in seven articles, is how safety culture is related to questions regarding safety management in general and leadership in particular. For example, Zou [21] explores safety programs at five construction companies in the United States, Australia, and Hong Kong with the purpose to map their implementation strategies and goals. The data collection consisted of a literature review, an analysis of public documents, and interviews and conversations carried out with company representatives. The results show that seven aspects characterize all programs and initiatives and that this,

taken together, contribute to a strong safety culture:

1. Focus is placed on shaping the attitudes concerning safety among the personnel and increasing the engagement in these matters to encourage safe behaviors.
2. The programs have a starting point in the notion that all incidents and work-related injuries can be prevented.
3. The company management shows a strong commitment to safety-related issues.
4. The programs include and involve all relevant parties (e.g., subcontractors) in safety-related issues.
5. The management system for safety is implemented to identify, evaluate, and remedy safety-related problems.
6. Clear division of roles and responsibilities as well as rewards being given for safe behaviors.
7. That there is a specific database were experiences regarding safety-related issues are systematized.

Chen and Jin [19] also study the importance of safety programs with a focus on the United States construction industry. By administrating a questionnaire focusing on managers, site managers and construction workers at 31 different construction sites in four states, the authors received 650 answers (71 from managers, 229 from site managers and 350 from workers). The focus of the study is on the effectiveness of the safety programs and how the programs are related to safety culture and safety climate. The authors conclude that the programs have a positive impact and illustrate this through a model showing that managers, when defining policies and procedures, contribute to safety culture. At the level of middle managers, these policies are then implemented and at this level there is also a safety culture which accepts the safety culture at the higher management level. At the third level, one finds the safety climate, i.e., how workers perceive the safety culture.

Safety investments in a broader sense have also been the subject of research. With a starting point in 47 construction projects in Singapore, Feng et al. [22] focus on the connections between safety investments (i.e., the total cost of safety work), safety culture and the level of risk within the company, as well as its effects on safety performance (i.e., accident frequency rates and injury severity). The study is based primarily on a statistical analysis of accident data as well as data from questionnaires. Feng et al. conclude that there are a number of different theories and models of the phenomenon available and how it can be measured. However, Feng et al. argue that there is consensus that the following ten variables can be used to operationalize the term: management commitment, communication and feedback, supervisory context, supportive conditions, performance requirements, personal assessment of risk, education and competency level, safety rules and procedures, workers' commitment, and assessment of work-related risks.

The study shows that safety performance in construction projects is determined by a combination of safety investments, safety culture and risk level in the project. By "safety investments", Feng et al. refer to everything that can be connected to investments at the construction site (including those made by subcontractors), for example education. Furthermore, Feng et al. differentiate between basic investments and voluntary investments in safety-related issues where voluntary investments include everything that a company does that is beyond the ordinary. Basic investments have a direct effect whereas the voluntary ones leads to improved safety culture that, in turn, leads to improved safety.

In a study of an Australian construction company, Biggs et al. [23] focus on how safety culture is perceived by individuals in management positions specifically. The leaders' definitions and descriptions of safety culture were mainly action-oriented, i.e., 'the way we do things around here'. Leadership was identified as a key factor for a positive safety culture, especially the importance of leaders showing a commitment for safety-related issues and that managers are readily visible for the workers. Regarding obstacles for changing safety culture, the large number of subcontractors was identified as an issue, as well as the high rate of change and the amount of administrative work overall. The results show that safety culture is a complex phenomenon that is hard to identify, even for experts within a given organization.

Wu et al. [24] focus on safety-related leadership among project owners, contractors, and subcontractors and how they interact with each other. The authors do not present a model of their own nor a specific definition of safety culture. Rather, they choose to capture the safety culture of the project by measuring safety climate with the following dimensions: managers' commitment, safety systems, communication, safety commitment, safety education and supervision, and environmental support. The study thus focuses on leadership for safety to a large extent. The authors take a starting point

in two types of leadership: transactional and transformational. Transactional leadership is related to surveillance and reward whereas transformational leadership focus on inspiring and motivating the personnel. Transformational leadership consists of four dimensions: idealized influence, inspiration and motivation, intellectual stimulation, and individual care. Transactional leadership, on the other hand, has two dimensions: temporary rewards and "management by exception". With a basis in this, Wu et al. identify four leadership styles: safety influence through good role models, safety motivation and coaching, safety work and individual respect, and safety management/performance management. The first three styles are connected to transformational leadership and the last one is connected to transactional leadership.

Dingsdag et al. [25] take a starting point in studies of safety culture and safety climate with a focus on how key personnel in construction companies can contribute to improved safety culture among the employees. The authors focus on the challenge regarding how safety-related competency issues are handled in the Australian construction industry where, with the exception of some requirements from the law, there are no unified approaches for how key personnel are trained in safety-related matters. The study explores 1) which roles or positions within companies that have the most influence on the behavior of the employees, 2) what types of initiatives that individuals in these roles/positions must take to drive the safety work forwards, and 3) how health and safety competence can be defined for critically important positions and roles within companies.

The authors conducted a survey at 11 main contractors in the Australian construction industry with 300 potential respondents from different occupational groups, out of which 107 answered. The questionnaire consisted of eight questions with a focus on what characterized the respondents' work and what they believed contributed most to the safety of the worksites, specifically what roles that contributed most to safety. The results show that the most important positions are: 1) health and safety coordinators (or similar roles), 2) supervisors, 3) union representatives, and 4) the workers themselves. Individuals in these positions should also have had received health and safety education, be good communicators and have significant experience of the industry. Dingsdag et al. [25] conclude that by identifying key positions and associated characteristics in construction companies, it is possible to improve safety through education efforts targeting those specific positions.

Finally, in a study in the United States construction industry, Gilkey et al. [26] conclude that the managers in the companies that were studied tended to assess the safety culture as being better compared to the workers' assessments. The managers also perceived that management commitment regarding safety issues was on a higher level compared to what the workers reported. No clear distinction is made between safety climate and safety culture in the study. Rather, they are both seen as related to eight aspects: 1) management commitment to safety, 2) the status among safety officers, 3) the status of the safety committee, 4) successful safety education, 5) risk levels in the workplace, 6) the effects of safe behaviors on social status, 7) the effects of safe behaviors on promotion, and 8) effects of performance demands on safe work. The authors argue that the safety climate is the result of policies and routines related to safety and how the workers perceive that these are prioritized by management, as well as how they are implemented in the daily work – especially by frontline managers when there are conflicting goals in the organization.

4. Discussion

The purpose of this article was to explore safety culture research conducted in the international construction industry. A number of studies address the complexity of construction-related work where main contractors, contractors and subcontractors interact on temporary worksites, on which they must coordinate their respective safety cultures. Each party contributes to the broader safety culture of the worksite, i.e., the safety culture that is unique to that particular construction project, through their own group-specific culture. An important aspect to consider in relation to this is the production process itself, both when it comes to the actual work being conducted and the logistics involved – or rather the multiple processes that can occur simultaneously under significant time pressure. Fundamentally, this complexity leads to safety culture being contextually determined and consequently that project-specific safety cultures need to be taken into consideration when studying the phenomenon.

As we mentioned in the introduction, safety culture is seen by many researchers as a subset of organizational culture – something that also holds true in research conducted in the construction industry. In the articles we studied for this literature review, it is fur-

thermore common to take a normative approach, i.e., that safety culture is something that actively can be developed and steered in a certain, desired direction. With such a view on safety culture, it thus constitutes the basic values and beliefs that guide members of a group in preventing risks and achieving safety [15]. It does not seem to be as common to take an interpretive approach, i.e., apply perspectives that are more neutral regarding the issue of whether culture itself leads to higher levels of safety if managed properly. There is also rarely any discussion about whether a focus on cultural factors that in a normative sense are seen as contributing to safety may lead to other cultural factors being downplayed or ignored. Fundamentally, there does indeed seem to be an emphasis on the change potential of safety culture in the research conducted in the construction industry.

In several of the models developed to describe and operationalize the safety culture of an organization, focus is placed on personal factors, i.e., how individuals perceive the safety system of an organization [see 8, 10, 18]. Another aspect is behavioral factors that describe what individuals actually do in the organization in relation to safety, as well as situational factors, i.e., the structures characterizing the organization. In line with this, the importance of leadership and management for safety culture is also addressed in several of the articles, especially management commitment for safety. For example, Wu et al. [24] make a distinction between transactional leadership, which is connected to monitoring and reward structures, and transformational leadership focused on inspiration and motivation. Transformational leadership, in particular, could be seen as being part of managers' own descriptions and definitions of safety culture as "the way we do things and the way we think about things" [23, p. 14]. We argue that the importance that is placed on leadership contributes significantly to the normative perspective on safety culture that is so prevalent in the research conducted in the construction industry, i.e., that safety culture development inevitably involves management processes in a top-down fashion throughout a given organization.

We can also conclude that much of the safety culture research in the construction industry, included in this review, apply research designs that favor quantitative methodologies. Although there are exceptions (see, e.g., [11], [23], [25]) there is, in general, a lack of anthropological and qualitative approaches, i.e., more interpretative perspectives. The benefit of applying a qualitative approach is that different parts of safety culture can be analyzed more thoroughly and without normative undertones. It could thus provide a more nuanced picture of what safety culture fundamentally consists of – for example, that different systems of meaning concerning safety may lead to the development of different types of safety cultures (see, e.g., [6] for an analysis of safety culture as being determined by different meanings placed on risk and preventive measures).

While the review points at interesting results it is however necessary to address a limitation that became evident during the course of our study, namely that the term "safety climate" was not included in the search phrase. As mentioned previously, Fang and Wu [10] underline that there has been a longstanding debate regarding the definitions of, and relationship between, safety culture and safety climate. Fang and Wu, however, argue that there is often consensus in the research community that measurements of safety climate through, e.g., questionnaires, could be seen as gaining an insight into important characteristics of safety culture. An example of such a tool is the Nordic Safety Climate Questionnaire [NOSACQ-50] developed by a group of researchers from Denmark, Finland, Iceland, Norway, and Sweden [27]. This questionnaire is comprised of 50 items spread across seven safety climate dimensions focusing on shared perceptions among group members of, e.g., management safety empowerment and workers' commitment to safety [28]. Since "safety culture" and "safety climate" is sometimes used interchangeably, an inclusion of this term could thus possibly have contributed to the authors finding more articles that fit the scope of the study regarding aspects such as the importance of certain types of management practices for safety in the construction industry.

5. Conclusion

Overall, the results of our literature review highlight that safety culture is a complex theoretical construct and that researchers focusing on the construction industry have come to favor certain perspectives on and definitions of the phenomenon. To broaden the understanding of safety culture, we suggest the following areas for further research:

The intricacy of safety culture as a phenomenon points to a need for qualitative studies focusing on participant observations, interviews, and document studies over a prolonged period.

The complexity of the construction industry points to a need for taking the socio-material context into

account when researching safety culture, for example by addressing matters related to the complexities of multi-employer and temporary, mobile worksites.

Organizational leaders' commitment to safety is highlighted in several of the studies that we reviewed for this article, and these studies are presented under the theme "Safety management and leadership as key-factors" [see for example 23, 24]. Relations between leadership and safety is also a common theme in the broader safety literature [29]. However, there is a need for further studies such as Gillen et al. [30] on how management and control practices – under the guise of safety culture development – are transferred down different hierarchical levels of given organization and interpreted by the workers themselves who, simultaneously, develop their 'own' cultural practices in their daily work.

There is a lack of scientific discussion about the importance of gender and macho masculinity in relation to safety culture. Some interest has been shown regarding masculinities and health and safety [31]. Given the male dominance within the construction industry, issues such as macho masculinity and risk taking, i.e., gendered aspects of safety culture, is a promising avenue for further research.

Ethical approval

Not applicable.

Informed consent

Not applicable.

Conflicts of interest

The authors declare that they have no conflict of interest.

Acknowledgments

Not applicable.

Funding

This research was supported by AFA Insurance under grant 190061.

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