SAFETY CLIMATE AS A MULTI-LEVEL AND DYNAMIC CONCEPT: EXPLORING THE VARIANCE AT DIFFERENT LEVELS OVER TIME

Payam Pirzadeh[1], Rita Peihua Zhang and Helen Lingard

School of Property, Construction and Project Management, RMIT University, GPO Box 2476, Melbourne VIC 3001, Australia.

Safety climate was measured longitudinally at a large-scale harbour expansion construction project. The project was commissioned by a single client and undertaken simultaneously by several principal contractors. Two waves of surveys measured participants' perceptions of safety at different levels, i.e. the client's safety response (CSR), the principal contractors' safety response (PCSR), and the supervisors' safety response (SSR). The results demonstrated significant between-site variance in workers' perceptions of PCSR and SSR in early project stage. However, at the later stage, the between-site variance was significant at all three levels. In contrast, the between-site variance in managerial/professional/supervisory personnel's perceptions of CSR and PCSR was significant both at the early and later stages. In this project, individual contractors implemented company-specific safety policies and procedures to meet the client's requirements. Moreover, supervisors locally implemented safety procedures using discrepant interpretations and context-specific action directives. Consequently, between-site variance was observed in PCSR and SSR. Due to the limited direct interactions with the client, workers may gradually form their perceptions of CSR through making sense of the project environment and interpreting safety messages conveyed by contractors and supervisors, causing between-site variance in CSR at later stages. The research provides preliminary evidence as to the impact of the characteristics of construction project organizational structures on shaping workers' perceptions about safety at various levels.

Keywords: dynamic, multi-level, safety climate.

INTRODUCTION

Safety climate

Hudson (2007) has suggested that the contemporary safety management efforts have moved into a 'culture stage', where the importance of cultural determinants of safety is emphasised. Safety culture has also been frequently identified, for example by disaster inquiries, as an underlying reason for an organization's success or failure in managing safety related aspects of its operations (Glendon and Stanton, 2000). Developing a positive culture for safety is seen as an important aspect of managing safety worldwide. For example, the Australian Work Health and Safety Strategy 2012 - 2022 establishes as one of its key action areas the need for 'Leaders in communities and organizations [to] promote a positive culture for health and safety' (Safe Work Australia, 2012).

[1] payam.pirzadeh@rmit.edu.au

Pirzadeh, P, Zhang, R P and Lingard, H (2016) Safety Climate as a Multi-Level and Dynamic Concept: Exploring the Variance at Different Levels Over Time. *In*: P W Chan and C J Neilson (Eds.) *Proceedings of the 32nd Annual ARCOM Conference,* 5-7 September 2016, Manchester, UK, Association of Researchers in Construction Management, Vol 1, 559-568.

Previous research has recommended that organizations that aim to foster organizational cultures that support safety can use safety climate measurement to monitor progress and identify opportunities for improvement (Zhang *et al.,* 2015). Safety culture and safety climate are two theoretically different but related concepts. Drawing upon Schein's (1985) organizational culture model, Glendon and Stanton (2000) suggested that cultural influence on safety is a complex and multi-layered phenomenon and that at the deepest level, the basic assumptions which permeate the whole organization, influence safety. The basic assumptions are deeply rooted, unconscious, and unspecific (Guldenmund, 2000). Individuals who hold these basic assumptions are likely to take them for granted and may not be able to recognize or articulate their assumptions. Nevertheless, the influence of these basic assumptions is manifested in the two outer layers, i.e. the beliefs and espoused values shared by individuals regarding safety at the intermediate level; and the observed safety-related behaviours and artefacts (e.g. safety documents, rules and procedures; managerial and supervisory actions) at the surface level. The two outer layers are rooted in and logically flow from the basic assumptions, and are reflected in safety climate (Guldenmund, 2000). It is believed that cultural influences on safety are expressed through safety climate, which can be uncovered by measuring employees' attitudes or perceptions (Guldenmund, 2000; Glendon and Stanton (2000)). Flin *et al.,* (2000, p178) suggest safety climate represents the 'surface features of the safety culture discerned from the workforce's attitudes and perceptions at a given point in time'. Consistent with this, safety climate has been defined as 'a summary of molar perceptions that employees share about their work environments' (Zohar 1980, p 96).

Multi-level measurement of safety climate

Safety climate can shape workers' behaviour through influencing the perception that workers form about how organizations reward and support safety (Lingard *et al.,* 2012). An increasing number of studies, conducted across various industries, have measured safety climate. Researchers in these studies expect to identify links between safety climate and safety-related behaviours and objective performance indicators (e.g. occurrence of incidents, injury rate). In the construction industry some studies have reported a significant link between safety climate and various aspects of safety performance (see, for example, Lingard *et al.,* (2012; 2010), Siu *et al.,* (2004), Zhou *et al.,* (2008)).

A recent study by Zhang *et al.,* (2015) highlighted that the majority of safety climate studies in the construction industry have used the 'organization' as the unit of analysis. This approach assumes that workers share homogeneous perceptions of safety roles and responsibilities across an organization. For example, Sui *et al.,* (2004) combined questions relating to workers' own safety attitudes with questions relating to colleagues', managers', safety officers' and supervisors' safety attitudes to create an aggregated safety climate score. However, Meliá *et al.,* (2008) suggested that safety climate should be differentiated at different levels in the construction environment. This is because the "safety agents" along the hierarchical construction supply chain (e.g. principal contractor, supervisor and workers) perform different safety responses, i.e. different safety activities or issues described in safety climate statements.

Consistent with Meliá *et al.,* (2008), there is empirical evidence showing that safety climate is formed at different organizational levels, and that the prevailing safety climate can vary significantly between organizational divisions or subunits (Zohar,

2000; Zohar and Luria, 2005; Lingard *et al.,*, 2009, 2010). According to Zohar (2000), safety climate should be interpreted as a multilevel construct. It is argued that policies and procedures are established by top management at the organizational level and are executed by supervisors at the subunit level, therefore the formation of safety climate stems from two sources: 1) formal policies and procedures related to organizational level analysis; and 2) supervisory practices related to group level analysis.

Because of supervisors' discrepant interpretations and local implementation of formal procedures, the perceptions of supervisory practices formed by workers in different subunits are likely to be different. Lingard *et al.,* (2009; 2010) tested Zohar's multilevel climate conceptualization in the construction industry, and provided evidence that subcontracted work groups in construction projects reported different safety climates relating to supervisory practices. Lingard *et al.,* also noted that perceptions of supervisory practices could be distinguished from shared perceptions of the principal contractor's organizational safety response.

Zhang *et al.,* (2015) observe that the majority of safety climate studies in the construction industry only focused on contracting companies without considering the role of clients in fostering a positive safety climate in the construction projects that they procure. As initiators of construction projects, clients make decisions about the project budget, timeline, project objectives and performance criteria, which can create pressure and constraints that significantly impact safety in the construction process (Lingard *et al.,* 2008). It is anticipated that clients are in the best position to drive cultural changes that lead to positive safety outcomes. In fact, the impact of clients on safety behaviour and performance in construction projects has been noted in earlier studies. For example, Haslam *et al.,* (2005) identified client requirements as a causal factor imposing originating influence on construction accidents. Huang and Hinze (2006) reported that project safety performance can be greatly improved through a range of client-led initiatives, such as setting contractual safety requirements, participating in safety recognition programs, monitoring safety performance, funding safety initiatives and participating in on-site safety activities. Accordingly, Zhang et al (2015) suggest that perceptions of the clients' safety response should be included as a distinct aspect of project-level safety climate in the construction project environment.

AIM

The aim of the research was to explore the safety climate at different organizational levels over the life of construction projects. Safety climate was assessed in terms of participants' perceptions of the client's safety response (CSR), the principal contractors' safety response (PCSR), and the supervisors' safety response (SSR).

RESEARCH DESIGN

Data collection

Longitudinal safety climate surveys were conducted at a large-scale harbour expansion construction project. The project was to reconfigure and redevelop the container terminal and freight facilities. The project was commissioned by a single client and undertaken simultaneously by several principal contractors. Works included construction of a new container handling terminal, civil works and landscaping, wharf construction, dredging, and upgrade of roads and services. The total budget was 1.6 billion dollars. The project duration was estimated to be 4 years.

The project was divided into different work packages with a contractor in charge of each work package. From the early stages of the project, the client identified safety as a key deliverable of the project and tried to send a clear message about the importance of health and safety to the project participants. The client developed a safety charter for the project and specified safety objectives which were communicated to the contractors. Two waves of data collection were undertaken at three principal contractors' sites. The three work packages were selected based on the criteria that: 1) they included the majority of the construction work, 2) similar procurement strategy (design and construct) was used for the selected work packages, and 3) researchers were able to get access to the construction sites for the longitudinal data collection. The first round of surveys was conducted at the early stage of the project. The second round of surveys was undertaken between five to eight months after the first survey.

A multilevel safety climate measurement tool was used to longitudinally assess safety climate at the construction project. Suggestions from Meliá *et al.,* (2008) were followed for the development of the tool, i.e. the tool comprised safety climate statements to analyse safety climate from the perspective of safety agents who take responsibility for a particular safety activity/issue. The client's safety response (CSR) was assessed by the measure of general management commitment to safety which was developed for the UK Health and Safety Executive by Davies *et al.,* (1999). At the principal contractor level, the global organizational-level safety climate scale developed by Zohar and Luria (2005) was adapted to assess the principal contractors' safety responses (PCSR). At the group level, supervisors' safety responses (SSR) were measured using the scale developed by Zohar and Luria (2005). This scale covers different interactions between supervisors and work group members through which supervisors indicate the priority of safety in relation to completing goals.

In each of the construction sites, the surveys were administered using the 'TurningPoint' automated response system using 'KeePad' hand held devices. Survey questions were projected onto a screen one by one and read out by a facilitator.

Table 1: Number of participants from each construction site in each wave of survey

	Wave 1 survey	Wave 2 survey
Construction site A	Construction workers: 41 Managerial, professional and supervisory personnel: 11	Construction workers: 58 Managerial, professional and supervisory personnel: 30
Construction site B	Construction workers: 10 Managerial, professional and supervisory personnel: 8	Construction workers: 35 Managerial, professional and supervisory personnel: 17
Construction site C	Construction workers: 3 Managerial, professional and supervisory personnel: 20	Construction workers: 40 Managerial, professional and supervisory personnel: 36

Participants were required to press a number on the hand held devices to indicate their responses to the statement in each survey question against a 5-point scale ranging from '1 = Strongly Disagree' to '5 = Strongly Agree'. The responses were anonymously saved in a spreadsheet. Missing values were replaced by the mean score for the relevant question. Participants included construction workers and managerial, professional and supervisory personnel. The number of participants involved in each survey for each of the construction sites is provided in Table 1.

For each individual survey, a mean safety response score was calculated by averaging the mean scores for all items relating to each safety climate level. The mean safety response score is an indication of participants' perceptions of overall safety effort by

the safety agent at each level. Mean safety response scores included mean scores for client's safety response (CSR), principal contractors' safety responses (PCSR) and supervisors' safety responses (SSR). Participants were divided into two groups: 1) construction workers, and 2) managerial, professional and supervisory personnel including senior managers, project managers, site managers, engineers and foremen. Separate mean safety response scores were calculated for each group.

Data analysis

The mean safety response scores derived from the two waves of the survey were plotted to graphically represent the data, and to compare the mean safety response scores at each level across the three construction sites. In addition, one-way analyses of variance (ANOVAs) were performed to assess whether the safety response differences between the construction sites were statistically significant at each level. Separate ANOVA analyses were performed for each of the participant groups.

RESULTS

Workers' perceptions of client's safety response (CSR)

Figure 1 shows the mean scores for workers' perceptions of the client's safety response (CSR) obtained from the two waves of survey at each of the three construction sites. The data indicates that workers' perceptions of the CSR generally declined in two construction sites (sites A and B) and improved in construction site C between the measurement periods. In addition, the value of mean scores for CSR in different sites ranges from 3.67 to 4.18 in the first survey and from 3.30 to 4.16 in the second survey. So, the range of values of CSR mean scores is larger in the second survey than the first survey. The one-way ANOVA indicated that the between-site variance in workers' perceptions of CSR was not statistically significant in the first round of surveys; however, the between-site variance in CSR became statistically significant in the second-round survey ($F(2, 130) = 19.661$, $p = 0.000$).

Managerial, professional and supervisory personnel's perception of CSR

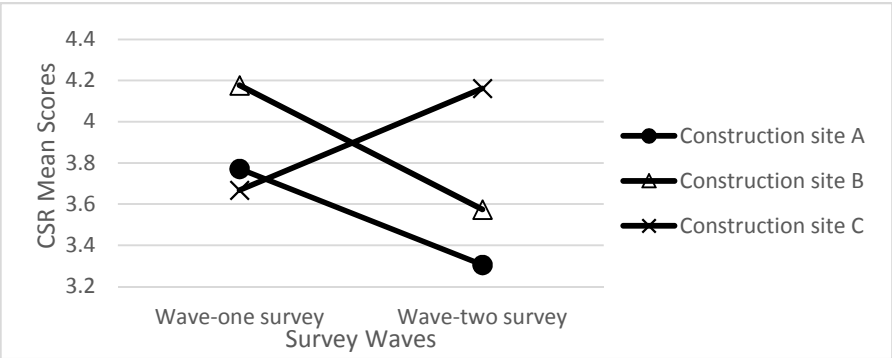

Figure 1: Comparative scores for workers' perceptions of CSR

Figure 2 shows the mean scores for the managerial, professional and supervisory personnel's perceptions of client's safety response (CSR) obtained from the two waves of survey at each of the three construction sites. The data indicates that the trends of change in managerial, professional and supervisory personnel's perceptions of CSR between the two waves of survey were similar to changes in workers' perceptions of CSR, i.e. the data shows a decline in perceptions of CSR for sites A and B and improvement in perceptions of CSR for site C. The one-way ANOVA indicated that the between-site variance in managerial, professional and supervisory personnel's perceptions of CSR was statistically significant in both the first-round (F

(2, 36) = 3.567, *p* = 0.039) and the second-round surveys (F (2, 80) = 8.183, *p* = 0.001).

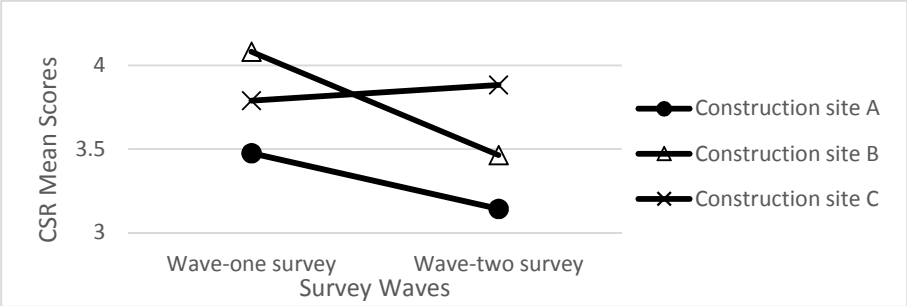

Figure 2: Comparative scores for managerial, professional and supervisory personnel's perceptions of CSR

Workers' perceptions of principal contractor's safety response (PCSR)

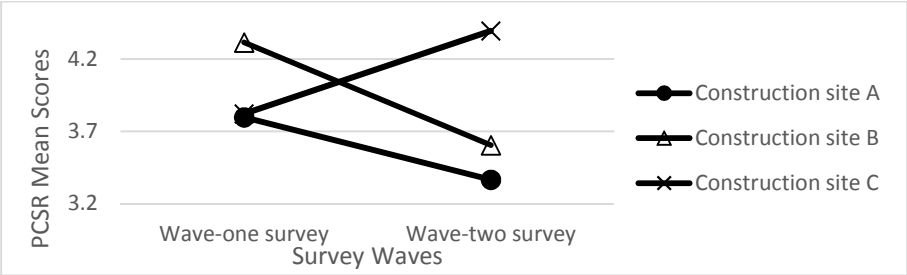

Figure 3: Comparative scores for workers' perceptions of PCSR

Figure 3 indicates the mean scores for workers' perceptions of principal contractors' safety responses (PCSR) obtained from the two waves of survey at each of the three construction sites. The data indicates that workers' perceptions of the PCSR showed a similar trend to changes in the CSR; that is, workers' perceptions of the PCSR declined at two construction sites (sites A and B) but increased at site C. In addition, the mean scores for the PCSR range from 3.80 to 4.32 in the first survey and from 3.37 to 4.40 in the second survey. So, the range of values of PCSR was larger in the second survey than the first survey. The one-way ANOVA indicated that the between-site variance in workers' perceptions of PCSR was statistically significant in the first round of surveys (F (2, 51) = 3.452, p = 0.039) and in the second-round survey (F (2, 130) = 45.127, p = 0.000).

Managerial, professional and supervisory personnel's perception of PCSR

Figure 4 indicates the mean scores for the managerial, professional and supervisory personnel's perceptions of the principal contractors' safety responses (PCSR) from the two waves of survey at each of the three construction sites. The data indicates a decline in the perceptions of the PCSR at sites A and B and an improvement at site C. The mean scores range from 3.60 to 4.22 in the first survey and from 3.43 to 4.33 in the second survey. In addition, the one-way ANOVA indicated that the between-site variance in managerial, professional and supervisory personnel's perceptions of the PCSR was statistically significant in the first round of surveys (F (2, 36) = 4.256, p = 0.022) and in the second round of surveys (F (2, 80) = 14.474, p = 0.000).

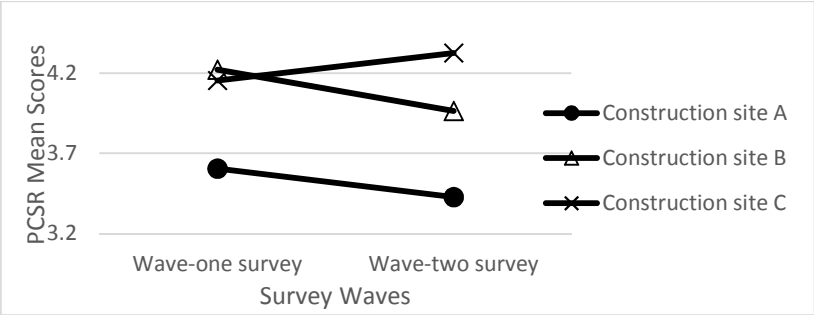

Figure 4: Comparative scores for managerial, professional and supervisory personnel's perceptions of PCSR

Workers' perceptions of Supervisors' Safety Response (SSR)

Figure 5 shows the mean scores for the workers' perceptions of their supervisors' safety responses (SSR) obtained from the two waves of survey at the three construction sites. The data indicates that workers' perceptions of SSR declined at two sites (sites A and B), and this decline was more dramatic at site B than at site A. In contrast, workers' perceptions of SSR improved at site C. The mean scores for perceptions of SSR range from 3.65 to 4.25 in the first survey and from 3.32 to 4.26 in the second survey; thus, the range of values of SSR scores was slightly larger in the second survey than the first survey. The one-way ANOVA indicated that the between-site variance in SSR mean scores was statistically significant in both the first survey ($F (2, 51) = 3.651$, $p = 0.033$) and the second survey ($F (2, 130) = 21.725$, $p = 0.000$).

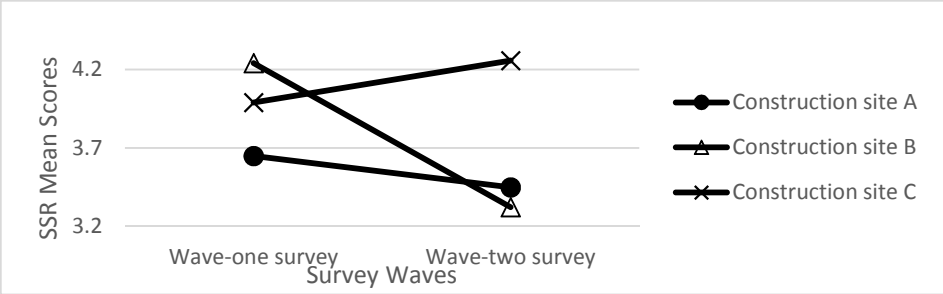

Figure 5: Comparative scores for workers' perceptions of SSR

Managerial, professional and supervisory personnel's perception of SSR

The data in relation to managerial, professional and supervisory personnel's perceptions of SSR was excluded from this study. This is because the managerial, professional and supervisory personnel in each site attended the same survey sessions as the workers and answered the same survey questions. The survey questions in relation to CSR and PCSR clearly asked about participants' perceptions of the client and the principal contractors' safety behaviours. Consequently, both the construction workers and the managerial/ professional/ supervisory personnel expressed their perceptions of the same concept as the client and the principal contactor were the same for all the participants from each construction site. However, the questions in relation to SSR asked participants' perceptions of their supervisors' safety behaviour. For the purposes of data collection, the research applied a definition of 'supervisor' as the person who gives day to day instructions to the participants in work. Thus, each of the professional/managerial/supervisory personnel could potentially have answered these questions in relation to a different person (depending on their level and position

within the organizational structure). As such, it was inappropriate to aggregate this data to reflect a shared perception of safety climate among this group.

DISCUSSION

Safety climate reported by workers

The research results demonstrate that at the early stage of the project, the between-site variance in the safety climate reported by workers was only significant at the lower levels (i.e. the principal contractor and the supervisor levels), but not at the higher level (i.e. the client level). However, at the later stage, the between-site variance in the safety climate reported by workers was significant at all the three levels. This could potentially be explained by the characteristics of project organizational structures in the construction industry. Specifically, in a hierarchical multi-level construction project organization, the workers have few opportunities to directly interact with the client. Therefore they are likely to form their perceptions of the CSR through perceiving the general safety atmosphere (e.g. the client's safety slogans and promotional materials posted around the site) at the project and interpreting safety messages transmitted by the principal contractor to understand the client's safety expectations. At the early stage of the project, workers at different construction sites appear to have developed homogeneous perceptions of CSR, possibly because they received similar safety messages and developed similar beliefs about the safety expectations set by the client for all three principal contractors working in the project.

Despite establishing a single over-arching safety framework for the project, the client left decisions about the way that this vision was operationalized to each of the principal contractors. Thus each of the principal contractors established their own safety policies and procedures to address the client's safety expectations. This may explain why workers at different construction sites developed different perceptions of their principal contractors' safety response (PCSR), even when it was in the early stage of the project. It is also possible that the between-site variance in the perceptions of PCSR contributed to the larger between-site variance in workers' perceptions of CSR in the later stage. It is possible that, as the project progressed, workers began to notice gaps between the slogans and statements made by the client and the way that safety policies and procedures were being operationalized at a local level.

These gaps may have modified their perceptions of the CSR over time, particularly as the client project management team placed greater emphasis on project schedule performance. There is a substantial body of research that suggests higher levels of safety climate have a shaping influence on lower levels of safety climate (see for example, Brondino *et al.*, 2012; Zohar and Luria, 2005). However, one explanation for the findings of this research is that workers may interpret a client's safety expectations through their perceptions of the principal contractors' safety activities and priorities. Furthermore, the research results indicate that workers at the different construction sites had significantly different perceptions of their supervisors' safety responses (SSR) in both waves of the survey. This variation may be due to differences in the local implementation of safety policies and procedures within workgroups, with supervisors possibly using discrepant interpretations and context-specific action directives (Zohar, 2000). Similar research findings in relation to SSR have been reported in previous studies in the construction industry (see, for example, Lingard *et al.,* (2009)).

Safety climate reported by professionals

Compared to construction workers, managerial/ professional/ supervisory personnel have more direct interactions with client personnel (e.g. in project management team meetings, formal and informal project communications, client site walks etc.). The research results revealed that managerial, professional and supervisory personnel at the different construction sites developed different perceptions of the CSR through various interactions, even from the early stages of the project. Unlike workers, site professionals do not merely perceive CSR by receiving indirect - often highly visible and generic - safety messages. In this project, although the client attempted to set similar safety requirements and expectations for all the principal contractors, professionals working in these principal contractor organizations appeared to reflect different understandings about what the client expected in terms of safety. Previous research indicates that what the senior managers "really want" is not always consistent with what is stated in official safety documents (Clarke, 1999). It is possible that the client at this project communicated mixed messages about the relative importance of safety to managerial, professional and supervisory personnel during their interactions. Also the research results show that managerial, professional and supervisory personnel at the different sites developed different perceptions of their own organizations' (i.e. the principal contractors') safety responses throughout the project. This difference, again, is potentially explained by variation in the way that the clients' safety framework was operationalized by the three principal contractors.

CONCLUSIONS

Safety climate is a complex and multi-level construct. In construction projects, there is evidence that safety climate is formed at different organizational levels, and can vary significantly between organizational divisions or subunits. At a high organizational level, the role of clients in fostering a positive safety climate has been highlighted. This is because clients are the initiators of construction projects and their decisions can significantly impact safety in construction process. Similarly, research evidence suggests that the higher level safety climate filters down and has a shaping influence on lower level safety climates. However, the present study suggests that over time, the relationship between the higher level safety climate and the lower level safety climate may, in fact, work in the opposite direction in construction projects. The research provides preliminary evidence that the characteristics of construction project organizational structures may shape workers' perceptions about the relative safety priorities of players at various levels. It highlights the potential for the local operational implementation of policies and procedures to modify perceptions of a client's global safety priorities over time.

REFERENCES

Brondino, M, Silva, S A and Pasini, M (2012) Multilevel approach to organizational and group safety climate and safety performance: Co-workers as the missing link. *Safety Science*, **50**(9), 1847-1856.

Clarke, S (1999) Perceptions of organizational safety: Implications for the development of safety culture. *Journal of organizational Behavior*, **20**(2), 185-198.

Davies, F, Spencer, R and Dooley, K (1999) *Summary Guide to Safety Climate Tools*. Offshore Technology Report: Health and Safety Executive.

Flin, R, Mearns, K, O'Connor, P and Bryden, R (2000) Measuring safety climate: Identifying the common features. *Safety Science*, **34**(1–3), 177-192.

Glendon, I and Stanton, N A (2000) Perspectives on safety culture. *Safety Science*, **34**(1-3), 193-214.

Guldenmund, F W (2000) The nature of safety culture: a review of theory and research. *Safety Science*, **34**(1-3), 215-257.

Haslam, R A, Hide, S A, Gibb, A G F, Gyi, D E, Pavitt, T, Atkinson, S and Duff, A R (2005) Contributing factors in construction accidents. *Applied Ergonomics*, **36**(4), 401-415.

Huang, X and Hinze, J (2006) Owner's role in construction safety. *Journal of Construction Engineering and Management*, **132**(2), 164-173.

Hudson, P (2007) Implementing a safety culture in a major multi-national. *Safety Science*, **45**(6), 697-722.

Lingard, H, Cooke, T, Blismas, N and Jellie, D (2008) *The Model Client: Promoting Safety Construction*. Canberra: The Office of the Federal Safety Commissioner, Australian Government.

Lingard, H, Cooke, T and Blismas, N (2009) Group-level safety climate in the Australian construction industry: Within-group homogeneity and between-group differences in road construction and maintenance. *Construction Management and Economics*, **27**(4), 419–432

Lingard, H, Cooke, T and Blismas, N (2012) Do perceptions of supervisors' safety responses mediate the relationship between perceptions of the organizational safety climate and incident rates in the construction supply chain? *Journal of Construction Engineering and Management*, **138**(2), 234-241

Meliá, J L, Mearns, K, Silva, S A and Lima, M L (2008) Safety climate responses and the perceived risk of accidents in the construction industry. *Safety Science*, **46**(6), 949-958.

Safe Work Australia (2012) *Australian Work Health and Safety Strategy 2012-2022*, Commonwealth Government of Australia, Canberra.

Schein, E H (1985) *Organizational Culture and Leadership*. San Francisco, CA: Jossey-Bass.

Siu, O.-l, Phillips, D R and Leung, T.-w (2004) Safety climate and safety performance among construction workers in Hong Kong: The role of psychological strains as mediators. *Accident Analysis and Prevention*, **36**(3), 359-366.

Zhang, R.P, Lingard, H and Nevin, S (2015) Development and validation of a multilevel safety climate measurement tool in the construction industry. *Journal of Construction Engineering and Management*, **33**(10), 818-839.

Zhou, Q, Fang, D and Wang, X (2008) A method to identify strategies for the improvement of human safety behavior by considering safety climate and personal experience. *Safety Science*, **46**(10), 1406-1419

Zohar, D (1980) Safety climate in industrial organizations: theoretical and applied implications. *Journal of Applied Psychology*, **65**(1), 96-102.

Zohar, D (2000) A group-level model of safety climate: Testing the effect of group climate on micro accidents in manufacturing jobs. *Journal of Applied Psychology*, **85**(4), 587-596.

Zohar, D and Luria, G (2005) A multilevel model of safety climate: Cross-level relationships between organization and group-level climates. Journal of Applied Psychology, **90**(4), 616.