Group-level Safety Climate in the Construction Industry: The Influence of Organizational, Group, and Individual Factors

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ABSTRACT

Group-level safety climate (GSC) is a recognized leading indicator of safety performance in the literature. However, there is limited understanding of the mechanisms through which multi-level (i.e. organizational, group, and individual) factors collectively influence GSC as promoted by general contractors in construction. A model is proposed to examine the interactions and causal relationships between four multi-level factors including organizational-level safety climate (OSC), co-worker support (CS), supervisory safety-specific transformational leadership (SSTL), individual psychological capital (PsyCap) and GSC. A two-wave online survey was conducted within a large contractor company in the United States over two years. A total of 280 employees completed both surveys. The analysis technique of structural

equation modeling was adopted to test hypotheses. The results show that OSC, CS, supervisory SSTL significantly contribute to GSC. In addition, supervisory SSTL and CS positively affect individual PsyCap, while PsyCap positively moderates the relationship between supervisory SSTL and GSC. The study suggests that construction contractors should consider implementing leadership and PsyCap interventions to cultivate a positive GSC that potentially leads to improved safety performance.

Keywords: safety climate, supervisory leadership, psychological capital, co-worker support, structural equation modeling

INTRODUCTION

The construction industry plays a critical role in the economic growth and employment of the United States (US). According to the Associated General Contractors of America (2019) data, general contractors, directly and indirectly, hire over 7 million workforces and create nearly $1.3 trillion value of structures yearly. Yet safety remains one of the biggest challenges in construction (Tixier et al., 2017). Over the past decade, the construction industry accounted for 18.4% of all workplace fatalities in the US, the highest percentage of any industry (BLS 2019). Meanwhile, the fatality rate in the US construction industry has shown slight improvement since the 2000s (CPWP 2018).

To push past such a performance plateau, the industry and academia have looked into safety initiatives that can provide early and proactive alerts to prevent adverse

events and promote preventive actions (Patel & Jha., 2016; Cheung et al., 2020; Xu et al., 2021). Safety climate has been repeatedly identified as a proactive indicator of safety outcomes (e.g., Clark, 2010; Lingard et al., 2013; Zhang et al., 2015). Safety climate was first conceptualized by Zohar (1980, p101) as "a unified set of cognitions regarding the safety aspects of the organization", which "reflects employees' shared perceptions about the relative importance of safe conduct in their occupational behavior." In other words, safety climate was initially regarded as an organizational-level measurement.

Zohar and Luria (2005) later expanded the safety climate measurement to multiple levels: group- and organizational-level. The rationale is that organizations are social systems built up by the interactions between individuals and groups in an organizational structure (Kozlowski and Klein 2000). The micro-and macro-levels of a work environment inform employees' perceptions concerning an organization's safety climate at different levels. In particular, organization-level safety climate (OSC) encompasses company formal policies and procedures developed by senior management, and group-level safety climate (GSC) relates to the supervisory practices that implement the proper procedures using context-specific directives (Zohar, 2000). Because supervisors interpret and implement formal procedures in varying ways, their subordinates in different workgroups subsequently develop different perceptions of supervisory practices.

Since the introduction of the multi-level safety climate model by Zohar and Lucia (2005), studies have found that GSC is more influential than OSC in predicting

safety performance (e.g. Zohar and Luria, 2005; Brondino et al., 2012; Prohst, 2015). Nevertheless, research in construction has still focused mainly on investigating OSC, the initially conceived measurement level of safety climate (e.g. Zhou et al., 2011; Hou et al., 2013; He et al., 2016). Lingard (2010; 2012) and Gao (2016) ventured beyond this precedent by investigating multi-level safety climate in construction. These studies found that GSC mediates the effect of OSC on safety outcomes (e.g. workgroup injury frequency rate). The mediating effect of GSC highlights the vital role of group supervisors, who play the role of a conduit between an organization and frontline workers and convey organizational safety priorities to frontline workers (Lingard et al., 2012). Yet limited studies have investigated the antecedents, mediators, and moderators of GSC in construction. Cheung and Zhang (2020) is one of few studies that have examined the cascading influence of organizational support on GSC in the construction industry. However, the study only examined the effects of organizational- and group-level factors on GSC, without considering the role of individual differences in GSC formation. From the social-ecological perspective individuals' safety-related perceptions and behavior are affected by various factors at multiple levels, such as intrapersonal, interpersonal, group, organizational, and community levels, and the multiple level influences interact with each other (Sallis et al. 2008). Consistently, Wu et al. (2007) pointed out that safety climate is the product of interactions between organizational and individual factors. Without understanding such interactions, construction firms have inadequate actionable knowledge to

develop effective and targeted interventions to improve GSC for achieving better safety outcomes.

The current study aims to address the above-identified gap in the literature by testing the extent to which organizational factors (i.e. OSC), group-level factors (i.e. CS and supervisory safety-specific transformational leadership (SSTL)), and individual factors (i.e. PsyCap) are related to cultivating group-level safety climate (GSC) at two-time points over two years. These factors were chosen based on the existing literature in a non-construction context. For instance, OSC was found to associate with GSC as OSC set the boundaries of how people interpret GSC through safety policies and procedures at the organizational level (e.g. Huang et al., 2017). Because CS and supervisory SSTL are socially proximate to workers, they affect how workers interpret the priority of safety in the group (e.g. Hardison et al., 2014). Finally, PsyCap as the individual factor has shown the effect on driving positive work behavior and organizational outcomes such as job satisfaction, work engagement, and safety performance (e.g. Hystad et al. (2014) and Wang et al. (2018). Specifically, it is proposed that OSC, CS, and supervisory SSTL directly affect GSC and that individual PsyCap moderates the effect of CS and supervisory SSTL on GSC, while CS and supervisory SSTL have positive associations with PsyCap.

LITERATURE REVIEW

Organizational level factors

Organizational-level safety climate (OSC)

As mentioned earlier, safety climate can be cultivated at organizational and group levels. Although supervisory differences can lead to variations in safety climate between workgroups, the variations may be limited to a certain extent since organizational-level safety policies and procedures have set the boundaries for group-level interpretations (Zohar and Luria, 2005). Supervisors are assumed to carry out the organizational policies and procedures in their group using discretionary directives but not to change them (Zohar and Luria, 2005). Accordingly, there should be an alignment between OSC and GSC, which suggests that OSC is likely to predict GSC. This proposition has been validated by Huang et al. (2017), who reported that OSC and GSC perceived by truck drivers are positively and strongly related. They interact in a supplementary way to promote safety behaviors. The positive association between OSC and GSC has been revealed in studies conducted in the construction industry (see, for example, Melia et al., 2008; Lingard et al., 2012). Based on the above argument, it is hypothesized that:

H1: OSC is positively associated with GSC.

Group level factors

Supervisory safety specific transformational leadership (SSTL)

Supervisors play an essential role in affecting safety-related outcomes within the workgroups that they lead (Hardison et al., 2014). In day-to-day operations, workers rarely contact their organizations' senior management but frequently interact with their supervisors, who provide them support and instruction. Bentley and Haslam (2002) contended that supervisors play an essential role in accident prevention because through

their frequent contact with workers, supervisors have the opportunity to notice unsafe conditions and actions that may cause accidents. In addition, Zohar and Luria (2005) argued that the expectations set up by supervisory practices affect workers' safety behavior to a greater extent than organization-level expectancies.

Driven by the critical role of supervisors in safety, there is increased emphasis on the influence of supervisors' leadership on safety performance, whereby transformational leadership has received the most interest (Barling et al., 2002; Zohar & Tenne-Gazit; 2008; Conchie & Donald, 2009; Mullen & Kelloway, 2009; Mullen et al. 2017). The concept of transformational leadership was originated from the discipline of organizational behavior. According to Bass (1985), a transformational leader positively influences subordinates by enhancing the awareness of the meaning of work, encouraging the pursuit of higher-order needs, and motivating the transcending of self-interest for the organization's benefit. Although general transformational leadership can produce positive safety outcomes (e.g., Inness et al., 2010; Lingard et al., 2019), SSTL has gained wider attention in the context of safety research due to its incremental power in predicting safety outcomes beyond the general transformational leadership model (Mullen & Kelloway, 2009).

SSTL originates from Barling et al. (2002), who modified ten general transformational leadership measurement items derived from the widely used Multifactor Leadership Questionnaire (Bass & Avolio, 1990) to reflect leadership behaviors specific to the development and promotion of a safe work environment. SSTL comprises five components, including: 1) idealized influence, i.e. supervisors are

committed to safety and act as safety role models; 2) inspirational motivation, i.e. supervisors motivate their subordinates to accomplish safety goals; 3) intellectual stimulation, i.e. supervisors encourage their subordinates to make safety suggestions and enhance safety performance; 4) individualized consideration, i.e. supervisors demonstrate genuine concerns about subordinates' safety and wellbeing; and 5) contingent reward, i.e. supervisors provide recognition and reward for good safety acts and behaviours (Barling et al., 2002; Kelloway et al., 2006).

Considerable research evidence has found a strong relationship between SSTL, safety climate, and safety performance. For example, Kelloway et al. (2006) reported that SSTL positively correlates with safety climate, which subsequently predicts accidents, incidents and injuries. Mullen and Kelloway (2009) suggested that offering managers SSTL training has improved workers' perceptions of safety climate and self-reported safety behaviors and reduced injuries experienced by workers. The positive association between SSTL and safety climate can be explained by Zohar's (2002) position that a supervisor's leadership behaviors suggest important clues for group members to evaluate the overall importance that the supervisor assigns to safety. The perceived prioritization of safety then informs employees' perceptions of safety climate within the workgroup. Supervisors with SSTL are likely to create a workgroup environment where safety is emphasized, safe practices are promoted, and efforts to improve safety are encouraged. Therefore, it is hypothesized that:

H2: Supervisory SSTL is positively associated with GSC.

Co-worker support (CS) for safety

Previous research indicates that in addition to individuals with formal hierarchical power (e.g. supervisor), those without formal hierarchical power (e.g. co-workers) can also shape the values and norms exiting in a workgroup (Lingard et al., 2011; Brondino et al. 2012). Notably, CS has been reported to exert a unique influence on employees' perceptions, attitudes, and behaviors beyond the influence of supervisors (Chiaburu & Harrison, 2008). Co-workers are important social influencers in workgroups, and workers make sense of the work environment through interacting and communicating with their co-workers (Zohar and Tenne-Gazit, 2008). Social proximity plays a role in the senses making process, i.e. workers tend to be more influenced by those co-workers who are socially close with them compared to those who are socially distant (Burt, 1976). In the specific context of safety, CS for safety plays a vital role in workgroup safety outcomes. In line with social learning theory as well as social information processing theory, when co-workers support safety in a workplace, they highlight and strengthen the importance of safe work practices as well as creating social cues that employees are expected to put in the effort to build a safe work environment (Turner et al., 2010). Accordingly, CS has been reported as a significant predictor of employee safety voice (Tucker et al., 2008) and the essential element to keep workers safe when under workload pressure (Turner et al., 2010). CS is also linked to workers' perceptions of a positive safety climate (Gillen, et al. 2002). This is because through frequent social interactions with co-workers who actively support safety, employees develop beliefs supporting high safety expectations in the work environment (Chiaburu and Harrison, 2008; Brondino et al. 2012). Therefore, it is hypothesized that:

H3: CS for safety is positively associated with GSC.

Individual level factors

Psychological Capital (PsyCap) – the antecedents

The concept of PsyCap has emerged as a crucial personal resource in the field of positive organizational behavior, and empirical research evidence shows that PsyCap can contribute to positive organizational outcomes, including but not limited to organizational commitment, job satisfaction, work engagement, and lower absenteeism (Donaldson & Ko, 2010). PysCap goes above human capital (i.e. "what you know") and social capital (i.e. "who you know") and places emphasis on "who you are" or even "who you are becoming" (Luthans et al., 2006; p. 388). PsyCap depicts an individual's positive psychological state of development with four underlying dimensions: (1) *self-efficacy*: showing the confidence to exert required effort to deal with difficult tasks; (2) *optimism*: making positive attributions about succeeding at present and in the future; (3) *hope*: demonstrating perseverance in achieving goals, and sometimes redirecting pathways to goals to succeed; and (4) *resilience*: bouncing back and even exceeding original states to attain success when facing problems and adversity (Luthans et al., 2004; Luthans et al., 2006).

Positive organizational behavior posits that PsyCap is a type of human resource cultivated for positive change in organizations (Donaldson & Ko, 2010). Research suggests that leadership behaviors are mechanisms through which individuals' PsyCap can be developed (Gooty et al., 2009; Eid et al., 2012; Hystad et al., 2014). Specifically, empirical evidence shows that transformational leadership behaviors contribute to

231 employees' PsyCap because transformational leaders positively influence followers to
232 perceive a positive future based on motivated effort and perseverance (Gooty et al.,
233 2009). Such a perception can create favourable conditions for PsyCap to thrive (Gooty
234 et al., 2009). Given that safety-specific transformational leadership (SSTL) is
235 transformation leadership in the safety context (Barling et al., 2002), it is anticipated
236 that supervisors' SSTL can enhance workers' PsyCap, which in turn facilitates workers'
237 positive safety attitudes and behaviors. Therefore, it is hypothesized that:

238 **H4:** Supervisory SSTL is positively associated with employees' PsyCap.

239 Research evidence also suggests that social support at workplace facilitates the
240 development of PsyCap in employees because it provides employees with the
241 confidence and hope to select different pathways to accomplish goals, serves as a
242 contextual resource for individuals to bounce back after setbacks, and encourages
243 employees to use a positive attributional style when an adverse event occurs (Luthans
244 et al., 2008). Social support relates to the perceptions of *"overall levels of helpful social*
245 *interaction available on the job" (*Karasek & Theorell, 1990; p69). Senior management,
246 supervisors or co-workers can provide it in the workplace.

247 According to social impact theory (Latané, 1981), the social impact of other
248 persons on an individual is determined by three attributes, i.e. *strength*, *immediacy*, and
249 *number of other people*. Given that employees have frequent contact and work closely
250 with co-workers who are also relatively larger in number than supervisors and managers,
251 co-workers are likely to have considerable social influence on individual employees.
252 Burt et al. (2008) suggested that co-worker support can motivate employees to develop

a caring attitude, i.e. care about others' safety in the workgroup. Co-worker support is also likely to contribute to employees' positive psychological states. Indeed, Nigah et al. (2010) reported that effective buddy schemes characterized by supportive socialization processes contribute to higher levels of employee PsyCap, which then leads to higher work engagement. In the context of safety, co-workers who support safety are likely to: share work experience and provide task-related assistance so that other employees develop the ability to cope with challenging issues and to work safely (self-efficacy); discuss past incidents (e.g. near misses) with others and build confidence in other employees that those incidents can be avoided in the future by understanding the causes and associated preventive strategies (optimism); follow safe practices while working and also remind others to do the same, which reinforces others' belief that safety is essential and a safe environment can be maintained through collective effort (hope); provide emotional support to others and help others to manage and recover from hardship (resilience). Therefore, it is hypothesized that:

H5: CS for safety is positively associated with employees' PsyCap.

Psychological Capital (PsyCap) as a moderator

Individual workers and their social interactions construct the social environment of a workplace. When workers are highly motivated in the form of PsyCap, it presents a substantial level of psychological resources that can promote positive safety outcomes in safety-critical organizations (Eid et al., 2012). For example, previous research shows that PysCap positively influences safety climate (Bergheim et al., 2013) and mediate the relationship between leadership behaviors and safety climate (Hystad et al., 2014).

Emerging research evidence also shows that PsyCap is an effective internal resource that aids individuals in alleviating the negative influence while reinforcing the positive influence of a work environment on their safety-related perceptions and behaviors, indicating the moderating role of PsyCap. For example, Wang et al. (2018) discovered that workers' PsyCap moderates the relationship between workplace safety-related stress and workers' safety behaviors in the construction industry. Specifically, when safety-related stress becomes higher, workers with high PsyCap levels decrease their safety behaviours less than those with low PsyCap levels. Safety climate is a social cognitive concept. The perceptions of safety climate are shaped by environmental attributes in the workplace social context (e.g. leadership behaviors and co-worker support) (Zohar & Luria, 2004). PysCap can likely augment the influence of environmental attributes on individuals' perception of safety in the workplace. Alternatively, PsyCap may strengthen the impact of supervisory leadership and co-worker support on group-level safety climate. Therefore, it is hypothesized that:

H6: PsyCap is a moderator to the relationship between SSTL and GSC.

H7: PsyCap is a moderator to the relationship between CS and GSC.

Based on the aforementioned research hypotheses, the present study proposes a hypothesized model to examine how OSC, CS, and supervisory SSTL directly affect GSC. In addition, the model examines whether CS and supervisory SSTL help build individual PsyCap, resulting in PsyCap moderating the effects of CS and supervisory SSTL on GSC.

RESEARCH METHOD

Constructs

The hypothesized model comprises five latent constructs, which were assessed by psychometrically validated scales presented in Appendix 1. The 3-items CS measurement was from Mueller et al. (1999). The 16-item OSC measurement and 16-item GSC measurement was Zohar and Lucia (2005). The 10-item SSTL construct was developed by Barling et al. (2002). The 24-item PsyCap construct was drawn from Luthans et al. (2007). In addition, social desirability was assessed by the 5-item Marlow-Crowne Social Desirability Scale (Strahan & Gerbasi, 1972). All the items were evaluated using a five-point Likert scale in which "1" stands for "*strongly disagree/not at all*", and "5" means "*strongly agree/always"*.

Sample

The questionnaire survey was taken place anonymously and voluntarily and was filled in by construction professionals from a top 20 construction contractor that involves building and infrastructure projects with an annual turnover of over $6 billion. The organization has businesses all over the US. A single firm was used for this research with the consideration of preventing the findings from being affected because of intra-organizational deviations such as cultural and structural contexts. This is a limitation associated with the study, which has been illustrated in the later section. All participants worked in at least one project site and have a supervisor when the survey was conducted. A total of 622 questionnaires were distributed via email in two-time points in 2017, 9 months apart from each other. At time point 1, employees

completed the online survey to evaluate social desirability, which was applied for controlling the potential common method variance, and supervisory SSTL and CS. At time point 2, participants responded to items measuring individual PsyCap, OSC, and GSC. 383 construction professionals participated in the first survey (a 61.9% response rate), and 332 of them participated in the second survey (a 53.6% response rate). 292 participants completed both surveys to create a longitudinal sample. By considering missing values, the total usable samples were 280. The sample size reaches the recommended threshold of 200 for conducting structural equation modeling (SEM) (Kline, 2015). The descriptive information of the usable samples is shown in Figure 1, i.e. 55.7% of respondents had work experience in the construction industry longer than 15 years, 25.7% worked at the contractor organization for above 15 years, 72.5% held a bachelor's degree or above, and 90.7% were male. Overall, most respondents have worked in the sector for a considerable amount of time.

[Fig.1. Demographic information of respondents]

Data Analysis

To examine the above hypotheses, this study adopted structural equation modeling (SEM). This technique is considered as a hybrid of factor analysis, multiple regression analysis, and path analysis. SEM is an appropriate technique for this study due to several reasons. First, it reveals the relationships between constructs and their measurement. Second, SEM calculates the interrelated dependence relationships among latent constructs. Third, it reports estimation errors. Fourth, it can portray a complete

set of relationships within a single model. Given these capacities, SEM has been applied widely to study causal relationship testing in fields such as social science and psychology (Kline 2015).

SEM is implemented through two stages: the measurement model stage and the structural model stage. The first stage validates whether a single latent variable could represent several measured items via confirmatory factor analysis (CFA), while the second stage evaluates the relationships among latent constructs using path analysis. The goodness of model fit indices evaluates the performances of the measurement and structural models. There are three categories of goodness-of-fit indices: absolute fit indices, incremental fit indices, and parsimonious fit indices. Their ideal thresholds are discussed and recommended by Hooper et al. (2008) and Kline (2015). Absolute fit indices consist of a value generated from a $\chi 2$ test, Root Mean Square Error of Approximation (RMSEA), and Root Mean Square Residual (RMR). Their corresponding ideal thresholds are lower than 0.050, 0.080 and 0.050, respectively.

Incremental fit indices include Comparative Fit Index (CFI), Normed Fit Index (NFI), Incremental Fit Index (IFI), and Adjusted Goodness-of-Fit Index (AGFI). Their corresponding ideal thresholds are greater than 0.900, 0.700, 0.900 and 0.700, respectively. Parsimonious fit indices include Parsimonious Normed Fit Index (PNFI), Parsimony Goodness-of-Fit Index (PGFI), and Parsimony Comparative Fit Index (PCFI). All of their corresponding ideal thresholds are greater than 0.500. To achieve a good model fit of the measurement model, a model can be modified by excluding problematic items, which were identified based on factor loadings and standardized

residuals. According to Hair et al. (2014), an item may become problematic when (1) factor loading is lower than 0.5; (2) standardized residuals are higher than |4.0|; and (3) standardized residuals are between |2.5| and |4.0| with the appearance of other problems such as factor loading lower than 0.7. In this study, the measurement model and structural model were tested using SPSS AMOS 24 software.

MEASUREMENT MODEL

Confirmatory factor analysis (CFA) was performed to assess the measurement model. Construct validity and goodness of model fit were used to determine the model fit. Construct validity covers both convergent validity and discriminant validity.

Convergent validity

Convergent validity measures the degree to which the multiple measurement items of a specific latent variable share the variance in common. High values indicate that the items are internally consistent and represent the intended latent variable (Hair et al. 2014). Convergent validity was examined and assessed with Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) in this study. The results are listed in Table 1. Specifically, Cronbach's alpha of each variable was greater than the threshold of 0.700 (Forenell and Larcker, 1981). The CR for each variable was above 0.700, the threshold recommended by Hair et al. (2014). The AVE for each variable was greater than 0.500, the threshold recommended by Kline (2015). The results suggest that the measurement model has adequate convergent validity.

[Table1. Convergent validity]

Discriminant validity

This validity measures how a construct is different from other constructs in the SEM model by calculating the degree it correlates with other constructs and how distinctly it exists as a unique construct (Hair et al. 2014). Discriminant validity is usually evaluated by comparing the value of the square root of AVEs for any two constructs with the magnitude of correlation between those two constructs. If the value of each square root of AVE is greater than all the corresponding correlation coefficients, the measurement model is considered to have sufficient discriminant validity (Hair et al. 2014). The value of square root of AVE for each variable is presented on the diagonal in Table 1, highlighted in bold. Table 1 also provides correlation coefficients below the diagonal. Table 1 indicates that the square root of AVE for each variable is greater than the correlation coefficients. This shows that the discriminant validity of the constructed measurement model is adequate and that each of all the constructs are distinct from other constructs.

Model Fit

Table 2 lists the values for three types of goodness of fit indices for the measurement model. All the indices exceeded the ideal thresholds, indicating a satisfactory fit for the measurement model.

[Table 2. Goodness-of-fit measures for the measurement model]

Common Method Bias (CMB)

Considering that all the data was collected the same way (online questionnaire survey), this study conducted a common method bias (CMB) test to examine whether there is a common factor that could influence the results. This factor may generate spurious observed correlations among constructs, thus resulting in CMB (Donaldson and Grant-Vallone 2002). One of the widely used common factors is social desirability. Due to social desirability, some people may under-report behaviors regarded as inappropriate while over-reporting behaviors considered appropriate. Using the data collected with the Marlow-Crowne Social Desirability Scale suggested by Strahan and Gerbasi (1972), this study applied the method of common latent factor (CLF) to separate social desirability from the constructs in the measurement model (Podsakoff et al. 2003). This method mainly checks the effects of common method bias on CR and AVE for each construct. As shown in Table 3, when considering social desirability, the CR and AVE for each variable are greater than the recommended thresholds of 0.700 and 0.500, respectively, suggesting that the measurement model demonstrates adequate construct validity. Moreover, comparing CR values and AVE values with and without considering social desirability, there was no difference above 0.05. Therefore, the common method bias had no significant influence on the measurement model.

[Table 3. The common method bias test of the measurement model]

STRUCTURAL MODEL

A structural model was established and examined to test the hypotheses. Table 4 provides information on the goodness of fit indices. Table 4 shows that all the

values of the goodness of fit indices were higher than their corresponding thresholds, indicating that the structural model obtained a good model fit. Moreover, the total variance explained is adequate for the endogenous constructs: $\gamma^2 = 60.6\%$ for the group-level safety climate as shown in Figure 2.

[Table 4. Goodness-of-fit measures for the structural model]

Direct Effect

The results of the hypothesis testing are presented in Table 5 and Figure 2. Five significant direct effects were identified, supporting Hypotheses H1 to H5. Specifically, the significant effect of organization-level safety climate (OSC) on group-level safety climate (GSC) ($\beta = 0.238$, $p < 0.001$) supports H1, showing that GSC improves with a stronger OSC. The supervisory safety-specific transformational leadership (SSTL) has a significant and positive influence on GSC ($\beta = 0.549$, $p < 0.001$), supporting H2. Co-worker support (CS) significantly and positively affects GSC ($\beta = 0.193$, $p < 0.001$), supporting H3. The effect of supervisory SSTL on employees' psychological capital (PsyCap) is significantly positive ($\beta = 0.374$, $p < 0.001$), supporting H4. Co-worker support (CS) has a significant and positive association with PsyCap ($\beta = 0.170$, $p < 0.05$), supporting H5.

[Table 5. Test results of the hypotheses]

[Fig. 2. Hypothesized model estimation results]

Moderation

443 The moderation effect measures whether the degree to which a relationship
444 between one variable and another variable would be affected by a third variable. The
445 interaction term coefficient (PsyCap * supervisory SSTL) is significantly positive (β =
446 0.107, p =0.017), indicating that PsyCap strengthens the relationship between
447 supervisory SSTL and GSC. Thus, H6 is supported. To facilitate an explicit
448 understanding of how PsyCap moderates the relationship between supervisory SSTL
449 and GSC, the result is graphically shown in Figure 3. As PsyCap increases, the slope
450 of the effect of supervisory SSTL on GSC becomes steeper, indicating that PsyCap
451 strengthens the effect of supervisory SSTL on GSC. However, the interaction term
452 coefficient (PsyCap * CS) is not significant (β = 0.059, p =0.185), suggesting that
453 PsyCap is not a significant moderator to the relationship between CS and GSC. Thus,
454 H7 is rejected.

455 [Fig. 3. Moderating effect of PsyCap on SSTL and GSC]

456

457 **DISCUSSION**

458 Research evidence has revealed that group-level safety climate (GSC) is a
459 stronger predictor of safety outcomes than organizational-level safety climate (OSC)
460 (e.g. Brondino et al., 2012, Prohst, 2015); therefore, this study sought to identify the
461 antecedents of GSC and associated influencing mechanisms that could enable
462 construction firms to develop more effective interventions and training programs to
463 enhance GSC. Building on a previous study by Cheung and Zhang (2020), which

focused on examining the role of organizational support in improving GSC, this study advances the body of knowledge by further demonstrating how organizational, group and individual psychological factors interactively contribute to the dynamics. Specifically, the results of the study confirm that OSC, co-worker support (CS), and supervisory safety-specific transformational leadership (SSTL) directly affect GSC and that individual psychological capital (PsyCap) moderates the effect of supervisory SSTL on GSC, while CS and supervisory SSTL contribute to the development of individual PsyCap.

Aligning with previous studies conducted by Melia et al. (2008) and Lingard et al. (2012), this study found that OSC has a positive association with GSC in the construction context. This result indicates that how safety is positioned at the organizational level affects how safety is enacted at the group level (Zohar and Luria, 2005). The result suggests that safety efforts at multiple organizational levels are required to create a safe work environment that is conducive to positive safety-related outcomes.

In addition to organizational factors (i.e. OSC), the present study demonstrates that group-level factors, i.e. SSTL and CS for safety, are essential for cultivating a positive GSC. Zohar and Luria (2004) argued that safety climate is a social-cognitive construct involving employees' perceptions of the types of behaviors expected to be rewarded and supported through their experiences of different organizational events (i.e. episodes through which employees make sense of their work environment). These events often involve interactions with their supervisors and co-workers.

Rentsch (1990, p.669) further elaborated that the "sense-making process involves observing organizational events, detecting or abstracting patterns of relationships among the events, and interpreting these events in psychologically meaningful terms". For instance, if supervisors consistently emphasize safety acts overproduction speed and reward safe work behaviors, employees will perceive that safety is prioritized and expected in their team, and thus they will behave more safely to comply with this safety expectation. By the same token, if employees perceive that their co-workers support safe work behaviors, frequently discuss how to work safely, and care about other's safety, they are more likely to positively respond to these social cues by putting in extra effort to create a safe work environment.

Indeed, this study not only found that supervisory SSTL and CS have a positive impact on GSC, but also revealed that SSTL and CS help to build employees' PsyCap, an individual-level factor comprised of personal optimism, self-efficacy, hope, and resilience. These findings are promising, given that PsyCap in a safety context is a topic that researchers are just beginning to explore (Stratman & Youssef-Morgan, 2019). This study also found that PsyCap positively moderates the impact of SSTL on GSC. Knowing the antecedents (i.e. SSTL and CS) of PsyCap could inform our understanding of how to help employees develop this positive psychological state. From a conceptual and empirical standpoint, the findings imply that how personal PsyCap operates at different levels can be associated with employees' contextual factors. For example, by practising SSTL, supervisors tend to:

1) demonstrate a high commitment to safety and act as good safety role models, which make subordinates believe the team can achieve positive safety outcomes, resulting in building their optimism in PsyCap;

2) motivate and inspire subordinates to accomplish challenging safety-related tasks, which can reinforce subordinates' belief in their ability to cope with challenging goals, resulting in developing self-efficacy in PsyCap as subordinates become confident that good safety performance can be accomplished, resulting in the development of hope in PsyCap; and

3) provide individualized safety support and mentoring to subordinates, developing subordinates' resilience in PsyCap when grappling with adversity. Furthermore, these results are aligned with Luthans et al. (2007), who concluded that a supportive organizational climate is essential for developing PsyCap, while interactions with supervisors and co-workers have a significant impact on how employees perceived organization climate (Dehring, Von Treuer & Redley, 2018).

In addition, the coefficient of determination (γ^2) equal to 60.6% in this study indicates that the proposed model explains a substantial degree of variance of GSC. By looking at the direct effects of all independent constructs in the model, supervisory SSTL obtains the highest beta coefficient (0.549). This result implies that supervisory SSTL has the most substantial impact on GSC compared to the other constructs in the model. This finding is not completely surprising as the incentives provided by superiors, such as personal attention and recognition, have been consistently identified

to induce the most substantial reinforcement effect in organizational culture and policies, exceeding material and social incentives (e.g. co-worker support) (Stajkovic & Luthans, 1997). Zohar and Luria (2003) assessed the implementation of behavioral safety interventions focusing on supervisors instead of individual workers, and found that such interventions significantly increased supervisory safety-oriented interactions with subordinates, contributing to improvements in worker's safety-related behavior and safety climate scores.

In addition to the significant direct effects, PsyCap was found to moderate the relationship between supervisory SSTL and GSC significantly. This result is aligned with cognitive theories of perception in which the formation of perception is a function of three classes of constructs: the objects or events being perceived, the environment in which perception occurs, and the individual doing the perceiving (Gelman and Au, 1996). In this study, GSC is the object being perceived, supervisory SSTL creates the environment in which employees' perceptions occur, and individuals with different PsyCap levels doing the perceiving. Specifically, through practising SSTL in daily operation, supervisors constantly send messages to their group members about their high safety expectations, thus enhancing the GSC. Meanwhile, high levels of PsyCap can strengthen this relationship because the greater the individuals' PsyCap, the higher their ability to implement safety standards and procedures, cope with difficulties in achieving safety goals, and conform with supervisory expectations regarding safety (e.g. Eid et al., 2012; Chen and Chen, 2014;

549 Wang et al., 2018). As a result, PsyCap helps individuals to reinforce the positive
550 influence of supervisory SSTL on cultivating GSC.

551 Furthermore, this study also investigated another environmental attribute, CS for
552 safety, and investigated whether PsyCap positively moderates the relationship
553 between CS and GSC. However, the moderation effect was not significant. Since
554 there is limited research on the moderation effect of PsyCap on the relationship
555 between environmental attributes (e.g. SSTL and CS) and safety climate, the reason
556 for this insignificant effect is not apparent. Further research is needed to investigate
557 why PsyCap only moderates the relationship between specific environmental
558 attributes and safety climate. Yet, this study shows that supervisors play a more
559 influential role than co-workers in shaping GSC. From a social-cognitive perspective,
560 workers' perception of safety climate is more strongly influenced by social
561 interactions with supervisors than with co-workers. This research finding suggests that
562 workers' individual resources, i.e. PsyCap, is likely to resonate with SSLT to
563 reinforce the supervisory influence on workers' safety perception.

564 **LIMITATIONS AND FUTURE RESEARCH**

565 Although this study sheds light on the mechanisms of how organizational, group
566 and individual factors cultivate GSC, some limitations need to be acknowledged.
567 First, the sample data of this research was collected from a large construction
568 organization to reduce the confounding effect caused by intra-organizational
569 differences such as cultural and structural contexts. As a result, the generalizability of

the results to other construction organizations of different sizes is restricted. Future research can examine the model for other organizations of various sizes in the construction supply chain or different high-risk industries. Validating the research model in different organizations and industries could help detect shared patterns in how different organization, group, and individual factors affect GSC and identify whether different patterns are because of varying company sizes or industry features. Secondly, since the study data was collected for two-time points from the same participant, the relationships among the constructs could be confounded by common method bias. Although the longitudinal research design and statistical control on social desirability were used to control the effects of common method bias, it is recommended that multiple data sources can be used for assessing each data point in future studies to solve the problem fundamentally. Thirdly, the study has only examined several factors influencing GSC. GSC is likely shaped by many other potential factors at the individual-, group- and organizational-levels. Future studies are encouraged to explore the determinants of GSC more extensively to inform more useful strategies for developing positive GSC. Finally, there are limitations to acknowledge regarding sample representativeness. Like other longitudinal studies, attribution may be an issue as the longitudinal sample could over-represent highly committed employees who are more concerned about the subject matters than others (Neal & Griffin, 2006).

CONCLUSION

Longitudinal studies examining how organizational, group and individual factors affect GSC are uncommon. The present study was conducted over two years during which supervisory SSTL and CS were measured before the measure of PsyCap, OSC, and GSC. Therefore, the study has contributed to the body of knowledge in terms of providing more substantial evidence on the causal relationships and underlying mechanisms than previous cross-sectional studies within the field.

The study provides both theoretical and practical implications. Theoretically, the research extends previous studies by examining the influences of multi-level factors on GSC and the interactions between the multi-level factors. In particular, this research is one of the first to explore the role of a personal resource, i.e. PsyCap, in the formation of GSC in the construction industry context, and found PsyCap has a positive moderation effect on the relationship between supervisory SSTL and GSC. This implies the practical need to improve individuals' PsyCap working in construction organizations for enhancing the impact of SSTL on GSC. Luthans et al. (2006) initiated the PsyCap Intervention (PCI) training model to increase the overall levels of PsyCap. PCI training was found effective in both organizational and academic settings (e.g. Georgiou et al. (2019) and Luthans (2012)). The training includes activities such as identifying career goals, understanding career pathways, developing obstacle planning, and activities influencing motivation such as building self-efficacy, developing positive expectancy, persuasion, and arousal (Luthans et al., 2010). The research also highlights the importance of supervisory SSTL and CS for safety, i.e. they not only positively influence safety climate within workgroups but

613 also contribute to the development of employee PsyCap, which in turn enhances the
614 relationship between supervisory SSTL and GSC. The research findings provide
615 evidence supporting construction industry efforts to establish useful intervention
616 programs to develop supervisors' SSTL and foster support among group members.
617 Leadership training can be a useful way to improve supervisors' SSTL skills. For
618 example, Mullen and Kelloway (2009) demonstrated that providing SSTL training
619 programs to supervisors effectively develops supervisory ability in promoting and
620 improving safety in workplaces. Burt et al. (2008) suggested that nurturing a caring
621 attitude among employees helps build support within workgroups. They also pointed
622 out that developing a caring attitude relies on how employees know their co-workers
623 and social interactions among employees. Therefore, construction organizations can
624 consider organizing informal social activities or events through which employees can
625 connect with co-workers outside of direct work activities to strengthen social ties and
626 facilitate the development of a sense of care and support among employees.

627 **DATA AVAILABILITY STATEMENT**

628 Some or all data, models or code that support the findings of this study are
629 available from the corresponding author upon reasonable request.

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