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

Group-level safety climate (GSC) has been recognized as a leading indicator of safety outcomes. However, little is known about the mechanisms by which multi-level (i.e. organizational, group and individual) factors collectively cultivate GSC in construction. A model was proposed to examine the interactions and causal relationships between four multi-level factors (i.e. organizational-level safety climate (OSC), co-worker support, supervisory safety-specific transformational leadership (SSTL) and individual psychological capital (PsyCap)) and GSC. Data were collected from 280 construction professionals at two time points over a 2-year period in the US using online questionnaire surveys. Structural equation modelling was employed to test the hypothesized model. The results showed that OSC, co-worker support, supervisory SSTL significantly contribute to GSC. In addition, supervisory SSTL and co-worker support positively affect individual PsyCap, which in turn positively moderates the effect of supervisory SSTL on GSC. The study suggests that construction firms should consider implementing leadership and PsyCap interventions to cultivate a positive GSC that potentially leads to improved safety outcomes.

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

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INTRODUCTION

The construction industry plays a crucial role in the United States' economy growth and employment. According to the data from Associated General Contractors of American (2019), the industry hired over 7 million employees and creates nearly $1.3 trillion worth of structures each year. Yet safety remains one of the biggest challenges in construction (Tixier et al., 2017). Over the past decade, the construction sector 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 little improvement since the 2000s (CPWP 2018).

To overcome such a performance plateau, the industry and academia have looked into using safety leading indicators to improve safety performance. Particularly, safety climate, has been identified as an important leading indicator of safety outcomes (e.g., Clark, 2010; Lingard et al., 2013; Zhang et al., 2015). Safety climate was first defined 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) expanded the measurement of safety climate to multiple levels: group- and organizational-level. The rationale is that organizations are social systems built up by the interactions between individuals and subunits in an organizational structure (Kozlowski and Klein 2000). The micro- and macro-levels of work environment inform employees' perceptions of multilevel safety climate. In

particular, organization-level safety climate (OSC) is in relation to formal policies and procedures developed by top management, and group-level safety climate (GSC) is in relation to supervisory practices that implement the formal procedures using context-specific directives (Zohar, 2000). Due to supervisors' discrepant interpretations and implementations of formal procedures, employees of different workgroups are likely to develop different perceptions of supervisory practices.

Since the introduction of multilevel 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, studies in construction have still largely focused on investigating OSC, the originally conceived measurement level of safety climate (e.g. Zhou et al.,2011; Hou et al., 2013; He et al., 2016). Lingard (2010; 2017) and Gao (2016) tried to break this norm by investigating multilevel safety climate in the construction industry. These studies found that GSC mediates the relationship between OSC and safety performance (e.g. workgroup injury frequency rate). Yet limited research has 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 focused on examining the effects of organizational- and group-level factors on GSC, without considering the role of individual differences in the formation of GSC. In fact, Wu et al. (2007) pointed out that safety climate was the product of interactions between organizational factors and individual factors. Without

66 understanding such interactions, there remains inadequate actionable knowledge for
67 construction firms to develop effective interventions to improve GSC for a better
68 safety performance.

69 The current study aims to address the above-identified gap in the literature by
70 testing the extent to which organizational factor (i.e. organizational safety climate
71 (OSC)), group-level factors (i.e. co-worker support (CS) and supervisory safety-
72 specific transformational leadership (SSTL)), and individual factor (i.e. psychological
73 capital (PsyCap)) are related to cultivating GSC at two time points over a 2-year
74 period. Specifically, it is proposed that OSC, CS and supervisory SSTL directly affect
75 GSC, and that individual PsyCap moderates the effect of CS and supervisory SSTL on
76 GSC, while CS and supervisory SSTL have positive associations with PsyCap.

77 **LITERATURE REVIEW**

78 ***Group-level safety climate (GS)***

79 The level of measurement of safety climate is historically rooted in organisational
80 level as this is how it was defined and operationalized by Zohar (1980). Since Zohar
81 and Luria (2005) expanded the measurement of safety climate to multiple levels:
82 group- and organizational-level, studies have found that GSC could be more
83 important than OSC in predicting safety performance. For example, Zohar and Luria
84 (2005) found that the relationship between OSC and individual safety outcomes was
85 fully mediated by GSC in their samples of 401 works groups in 36 companies across
86 sectors. Brondino et al. (2012) also revealed that GSC, created by the interactions

between supervisors and co-workers, imposed a stronger effect on worker's safety behaviors than OSC in a study of 991 blue-collar workers from five different Italian manufacturing companies. Similarly, Prohst (2015) concluded that GSC appears to be particularly important to reduce employee underreported accidents when they worked in organizations with poor OSC based on the data analysis of 1,238 employees from 33 organizations in different industries. Although GSC was found to have a stronger impact on safety outcomes, studies in construction have still focused more on investigating OSC. Consequently, there is insufficient understanding of the antecedents, mediators and moderators of GSC in construction.

Organizational level factor

Organisational-level safety climate (OSC)

As mentioned earlier, safety climate can be formed at organizational level and group level. Although supervisory discretion can lead to variations in safety climate between workgroups, the variations are limited to certain extent, because safety policies and procedures developed at the organizational level have set the boundaries for permissible group-level interpretations (Zohar and Luria, 2005). Supervisors are expected to implement the formal policies and procedures within their workgroup using discretionary directives but not change or redefine them (Zohar and Luria, 2005). Accordingly, organization-level safety climate (OSC) and group-level safety climate (GSC) should be generally aligned, which suggests that OSC is likely to predict GSC. This proposition has been supported by Huang et al. (2017), who reported that OSC and GSC perceived by truck drivers are positively and strongly related and they interact

in a supplementary way to promote safety behaviors. The positive association between organization-level safety climate and group-level safety climate has also 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: Organization-level safety climate (OSC) positively affects group-level safety climate (GSC)

Group level factors

Supervisory safety specific transformational leadership (SSTL)

Supervisors play a critical role in affecting safety-related outcomes within workgroups that they lead (Hardison et al., 2014). In the day-to-day operations, workers rarely interact with senior management of their organizations but have frequent interactions with their supervisors who give them daily guidance and instruction. Bentley and Haslam (2002) claim that supervisors are the key individuals in accident prevention, because through frequent contact with workers they have the opportunities to notice unsafe conditions and acts that may cause accidents. In addition, Zohar and Luria (2005) argue that shared expectancies in relation to supervisory practices act as a more powerful and proximal antecedent to workers' safety behaviour than organization-level expectancies.

Driven by the important role of supervisors in safety, there is an increasing research interest in the influence of supervisory leadership styles and behaviors on safety performance, with a strong focus on the positive influence of transformational leadership on safety (Barling et al., 2002; Zohar & Tenne-Gazit; 2008; Conchie &

Donald, 2009; Mullen & Kelloway, 2009; Mullen et al. 2017). According to Bass (1985), a transformational leader engages subordinates by making them more aware of the meaning of work, by activating their higher-order needs, and by inducing them to transcend self-interest for the benefit of organization. Transformational leadership comprises four components, including: 1) *idealised influence*: leaders behave in a manner that makes them serve as role models for subordinates; 2) *inspirational motivation*: leaders motivate and inspire their subordinates by providing meaning and challenge to their subordinates' work; 3) *intellectual stimulation*: leaders stimulate their subordinates' efforts to be innovative and creative, and expand their subordinates' abilities to improve performance; and 4) *individual consideration*: leaders pay attention to each individual subordinate's needs for achievement and development as a coach or mentor (Bass, 1985).

Although general transformational leadership can produce positive safety outcomes (see for example, Inness et al., 2010; Lingard et al., 2019), safety-specific transformational leadership (SSTL) has gained wider attention in the context of safety research due to its incremental contribution in the prediction of safety outcomes beyond the general transformational leadership (Mullen & Kelloway, 2009). SSTL was originated from Barling et al. (2002), who modified ten general transformational leadership measurement items derived from the widely used Multifactor Leadership Questionnaire (Bass & Avolio, 1990), so that the items reflect leadership behaviors that are specific to the development and promotion of a safe work environment. Supervisors who demonstrate SSTL "*take an active and inspirational approach to safety issues,*

153 *serving as good models of safety behaviour and encouraging others to work in a safe*
154 *manner*" (Kelloway et al., 2006, p78).

155 Considerable research evidence has been documented regarding the strong links
156 between safety-specific transformational leadership (SSTL), safety climate and other
157 safety outcomes. For example, Kelloway et al. (2006) reported that SSTL positively
158 affects safety climate, which subsequently predicts safety events and injuries. Mullen
159 and Kelloway (2009) demonstrated that providing managers with safety-specific
160 transformational leadership training has led to improvements in workers' perceptions
161 of safety climate and self-reported safety behaviors, and reductions in injuries
162 experienced by workers. The positive association between SSTL and safety climate can
163 be explained by Zohar's (2002) argument that a supervisor's leadership behaviors
164 provide important clues for group members to ascertain the overall priority that the
165 supervisor assigns on safety. The perceived safety priority then informs employees'
166 perceptions of safety climate within the workgroup. Supervisors with SSTL are likely
167 to create a workgroup environment where safety is emphasized, safe practices are
168 promoted, and efforts to improve safety are encouraged. Therefore, it is hypothesized
169 that:

170 **H2**: Supervisory safety-specific transformational leadership (SSTL) positively
171 affects group-level safety climate (GSC).

172 ***Co-worker support (CS) for safety***

173 Previous research indicates that apart from individuals with formal power (e.g.
174 supervisor), those who do not have formal power (e.g. co-workers) also have influence

on group values and norms (Lingard et al., 2011; Brondino et al. 2012). Particularly, co-worker support has been reported to exert a unique influence on the perceptions, attitudes and behaviors of employees that is beyond the influence of supervisors (Chiaburu & Harrison, 2008). In the specific context of safety, co-worker support for safety plays an important role in workgroup safety outcomes. In line with social learning theory and social information processing theory, when co-workers in the work environment support safety, they reinforce the importance of safe work practices and provide social cues that employees are expected to put in effort to maintain a safe work environment (Turner et al., 2010). Accordingly, co-worker support has been identified as a predictor to employee safety voice (Tucker et al., 2008), and the most critical factor in keeping workers safe when under workload pressure (Turner et al., 2010). Co-worker support is also linked to the 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 would develop the beliefs about high safety expectations in the work environment (Chiaburu and Harrison, 2008; Brondino et al. 2012). Therefore, it is hypothesized that:

H3: Co-worker support (CS) for safety positively affects group-level safety climate (GSC).

Individual level factor

Psychological Capital (PsyCap) – the antecedents

196 The concept of psychological capital (PsyCap) has emerged as important
197 personal resources in the field of positive organizational behaviour, and empirical
198 research evidence shows that PsyCap can contribute to positive organizational
199 outcomes such as job satisfaction, organizational commitment, work engagement,
200 lower absenteeism (Donaldson & Ko, 2010). PysCap goes beyond human capital (i.e.
201 what you know) and social capital (i.e. who you know) and is concerned with 'who you
202 are' or even 'who you are becoming' (Luthans et al., 2004; Luthans et al., 2006).
203 PsyCap has been defined as an individual's positive psychological state of development
204 and has four underlying dimensions: (1) *self-efficacy*: having the confidence to put in
205 necessary effort to complete challenging tasks; (2) *optimism*: making positive
206 attributions about succeeding now and in the future; (3) *hope*: persevering toward goals,
207 and if necessary redirecting paths to goals in order to succeed; and (4) *resilience*:
208 bouncing back and even beyond original states to attain success when encountering
209 problems and adversity (Luthans et al., 2004; Luthans et al., 2006).

210 Positive organizational behaviour posits that PsyCap is a type of human
211 resources that can be cultivated for positive changes in organizations (Donaldson & Ko,
212 2010). Research suggests that leadership behaviors are mechanisms through which
213 individuals' PsyCap can be developed (Gooty et al., 2009; Eid et al., 2012; Hystad et
214 al., 2014). Specifically, empirical evidence shows that transformational leadership
215 behaviors contribute to employees' PsyCap because transformational leaders were
216 found to have positive contextual force that enables followers to perceive a positive
217 future based on motivated effort and perseverance. Such a perception can create

favourable conditions for PsyCap to thrive (Gooty et al., 2009). Given that safety-specific transformational leadership (SSTL) is transformation leadership in the safety context (Barling et al., 2002), it is anticipated that supervisors' SSTL would enhance workers' PsyCap which in turn facilitates workers' positive safety attitudes and behaviors. Therefore, it is hypothesized that:

H4: Supervisory safety-specific transformational leadership (SSTL) positively affects employees' psychological capital (PsyCap).

Research evidence also suggests that social support at workplace facilitates the development of PsyCap in employees, as social support provides employees with the confidence and hope to seek out new and alternative pathways to accomplish goals, serves as a contextual resource for individuals to bounce back after setbacks, and encourages employees to use a positive attributional style when a negative event occurs (Luthans et al., 2008). Social support concerns the perceptions of "*overall levels of helpful social interaction available on the job*" (Karasek & Theorell, 1990; p69) and it can be provided by top management, supervisors or co-workers at the workplace.

According to the social impact theory (Latané, 1981), social impact of other persons on an individual is determined by three attributes, i.e. *strength*, *immediacy*, and *number of other people*. Given that employees have frequent contact and work closely with co-workers who are also relatively larger in number compared to supervisors and managers, co-workers are likely to have considerable social influence on individual employees. Burt et al. (2008) suggest that co-worker support can motive employees to develop a caring attitude, i.e. caring 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 characterised 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 instil the confidence in other employees that those incidents can be avoided in future by understanding the causes and associated preventive strategies (optimism); follow safe practices in work and also remind others to do the same, which reinforces others' belief that safety is important 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: Co-worker support (CS) for safety positively affects employees' psychological capital (PsyCap).

Psychological Capital as a moderator

The social environment of workplace is constructed by individual workers and their social interactions, and positive worker motivation in the form of PsyCap presents a significant resource in promoting 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 acts as a mediator to 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 facilitates individuals in alleviating the negative influence while reinforcing the positive influence of 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 moderated the relationship between workplace safety-related stress and workers' safety behaviors in the construction industry, i.e. safety behaviors of workers with high PsyCap decrease less when safety-related stress increases, compared to workers with low PsyCap. Safety climate is a social cognitive concept and workers' 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). It is likely that PysCap can augment the influence of environmental attributes on individuals' perception of safety in the workplace. In other words, PsyCap may reinforce the influence of supervisory leadership and co-worker support on group-level safety climate. Therefore, it is hypothesized that:

H6: PsyCap moderates the relationship between SSTL and group-level safety climate

H7: PsyCap moderates the relationship between co-worker support and group-level safety climate.

Based on the proposed research hypotheses, the presented work hypothesizes a model to explore 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 effect of CS and supervisory SSTL on GSC.

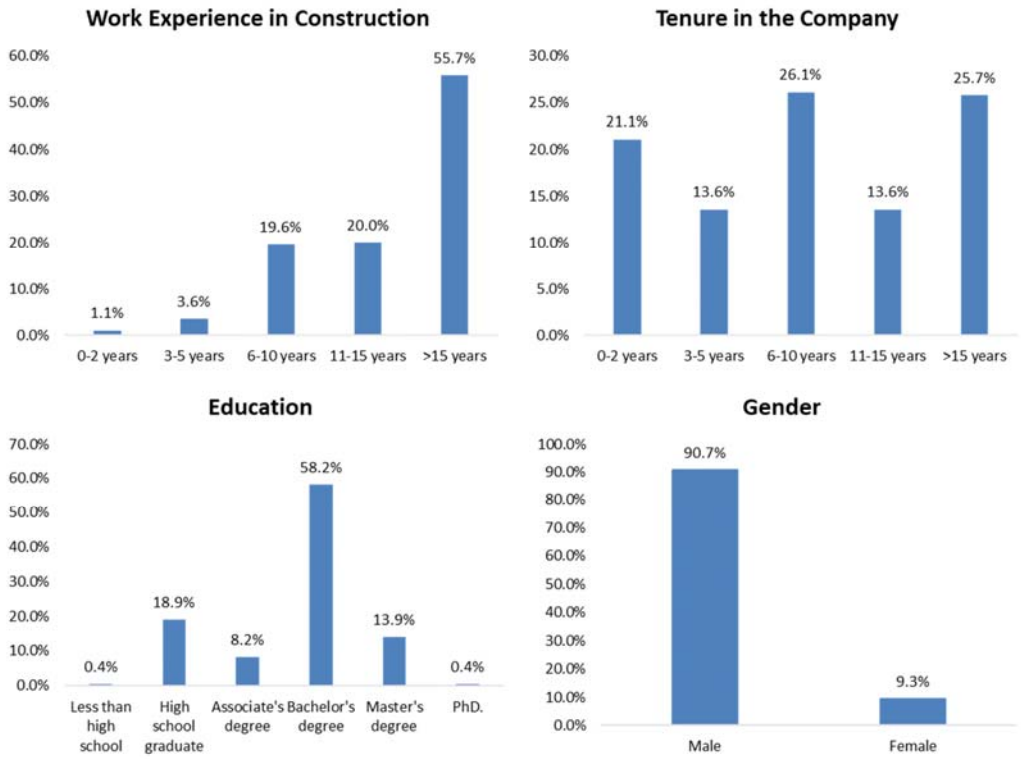
RESEARCH METHOD

Sample and Procedure

The questionnaire survey was completely anonymous and voluntary, and was completed by construction professionals who worked at a large US-based construction contractor, which works for commercial and civil projects with annual revenue over $5 billion. The company has business units and construction projects across the US. A single large organization was targeted for this study because it could prevent the findings from the effect of variations due to intra-organizational differences such as culture and structure. Yet, the limitations of the design are illustrated in the later section. Participants were selected based on the criteria that they were working in at least one construction site and having a supervisor when the survey was conducted. A total of 619 questionnaires were distributed using emails in 2016 (Time 1), and in 2017 (Time 2). In 2016, employees completed a measure of social desirability, which was used to control for potential common method variance, as well as the measures of supervisory safety-specific transformation leadership (SSTL) and co-worker support (CS). In 2017, participants responded to items concerning individual psychological capital (PsyCap), organizational-level safety climate (OSC), and group-level safety climate (GSC). 383 staff completed the first survey (a 61.9% response rate), and 332 staff completed the second survey (a 53.6% response rate). Both of the two surveys

were completed by a longitudinal sample of 292 employees. By eliminating missing values, the total usable responses were 280. The sample size is favorable for structural equation modeling (SEM) analysis that requires a minimum of 200 responses (Kline, 2015). According to the descriptive analysis on the usable samples as shown in Figure 1, 55.7% respondents worked in the construction industry for over 15 years, 25.7% worked at the company for over 15 years, 72.5% completed a bachelor's degree or above, and 90.7% were male. Overall, the majority of the respondents have worked in the industry for a considerable amount of time, which enhanced the quality of the survey data and the persuasiveness of the following analysis results to some extent.

Fig. 1. Statistics on the 280 valid respondents in terms of work experience in the industry, tenure in the company, education, and gender



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317 **Data Analysis**

318 To examine the above hypotheses, this study adopted the analysis technique of
319 structural equation modeling (SEM). This technique includes statistical methods
320 including factor analysis, multiple correlation analysis, multiple regression and path
321 analysis. SEM is an appropriate technique for this study due to several reasons. First, it
322 unveils the underlying relationship between latent variables and their measure items.
323 Second, it calculates the interrelated dependence relationships among latent variables.
324 Third, it reports estimation errors. Forth, it is able to illustrate a completed set of
325 relationships within a single model. Given these capacities, SEM has been applied
326 widely to study causal relationship testing in the field such as social science and
327 psychology research (Kline 2015).

SEM mainly includes two stages: the measurement model and the structural model. The first stage examines whether a single latent variable could be represented by several measured items via confirmatory factor analysis (CFA) while the second stage evaluates the associations and possible causal relationships among latent variables by a path analysis. The performances of both the measurement and structural models are assessed by the goodness of model fit. There are three types of goodness-of-fit indices, namely 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 $\chi 2$ 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 contain 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 satisfy the goodness of model fit of the measurement model, model modification may be conducted 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 lower than 0.5; (2) standardized residuals higher than $|4.0|$; and (3) standardized residuals 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

The measurement model was tested by confirmatory factor analysis (CFA) using construct validity and goodness of model fit. Construct validity includes 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 the items are internal consistent and able to represent the intended latent variable (Hair et al. 2014). Convergent validity was examined and assessed by the Cronbach's alpha, composite reliability (CR) and average variance extracted (AVE) in this study. The results are presented in Table 1. The Cronbach's alpha of each variable was greater than 0.700, the threshold recommended by Fornell and Larcker (1981). The CR for each variable was above 0.700, the threshold recommended by Hair et al. (2014). Besides, the AVE for each variable was greater than 0.500, the threshold recommended by Kline (2015). All the results suggest that the measurement model has adequate convergent validity.

Table 1. Construct validity

(Square root of the AVE on the diagonal and correlations between two variables are below it)

Variables	Cronbach's alpha	CR	AVE	GSC	OSC	Supervisory SSTL	PsyCap	CS
GSC	0.965	0.966	0.659	**0.812**				
OSC	0.934	0.935	0.507	0.570	**0.712**			
Supervisory SSTL	0.948	0.950	0.681	0.696	0.474	**0.825**		
PsyCap	0.926	0.877	0.644	0.387	0.488	0.423	**0.803**	
CS	0.887	0.894	0.739	0.444	0.327	0.332	0.293	**0.860**

Note: AVE= average variance extracted; CS=Co-worker Support; CR=composite reliability; GSC=Group-level safety climate; OSC=Organisational-level safety climate; PsyCap=psychological capital; SSTL=Safety Specific Transformational leadership

Discriminant validity

Another type of construct validity is discriminant validity. This validity reflects the degree to which a variable is distinct from other variables through how much it correlates with other variables and how distinctly it exists as a unique variable (Hair et al. 2014). Discriminant validity is usually evaluated by comparing the square root of AVEs for any two variables with the correlation coefficient between those two variables. If 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 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 of each variable is indeed larger than the correlation coefficients. This shows that the convergent validity of the constructed measurement model is adequate and each of all variables is distinct from other variables.

Goodness of Model Fit

Table 2 illustrates the three types of goodness of fit indices for the measurement model: $\chi 2$ test = 0.000; RMSEA = 0.053; RMR = 0.034; CFI = 0.901; NFI = 0.801; IFI = 0.901; AGFI = 0.723; PNFI = 0.766; PGFI = 0.687; PCFI = 0.862. All the indices exceeded the ideal thresholds, indicating a satisfactory fit for the measurement model.

Table 2. Test results of goodness-of-fit measures for the measurement model

Index name	Measure	Threshold	Hypothetical model	Evaluation
Absolute fit index	$\chi 2$ test	<0.05	0.000	Excellent
	RMSEA	<0.08	0.053	Excellent
	RMR	<0.05	0.034	Excellent
Incremental fit index	CFI	>0.9	0.901	Good
	NFI	>0.7	0.801	Excellent
	IFI	>0.9	0.901	Good
	AGFI	>0.7	0.723	Good
Parsimonious fit index	PNFI	>0.5	0.766	Excellent
	PGFI	>0.5	0.687	Excellent
	PCFI	>0.5	0.862	Excellent

Note: AGFI = adjusted goodness-of-fit index; CFI = comparative fit index; IFI = incremental fit index; NFI = normed fit index; PCFI = parsimony comparative fit index; PGFI = parsimony goodness of fit index; RMR= non-root mean square residual; RMSEA = root mean square error of approximation.

Common Method Bias (CMB)

Considering all the data was collected by the same means (online questionnaire survey), this study conducted a common method bias (CMB) test to examine whether there is a common factor, which would exert influences on the results. This factor may generate spurious observed correlations among variables, thus resulting in CMB (Donaldson and Grant-Vallone 2002). One of widely used common factors is social desirability. Due to social desirability, some people would under-report behaviors regarded as inappropriate while over-report behaviors considered as appropriate. Based

on the collected data on the Marlow-Crowne Social Desirability Scale (Strahan and Gerbasi 1972), this study applied common latent factor (CLF) method to separate social desirability from the variables 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, all CR and AVE for each variable are greater than the recommended thresholds of 0.700 and 0.500 respectively, suggesting that the measurement model have sufficient construct validity. Moreover, by comparing CR values and AVE values without and with considering social desirability, there was no difference above 0.05. Therefore, the common method bias did not significantly affect the measurement model.

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

	Without social desirability		With social desirability	
Variables	CR	AVE	CR	AVE
GSC	0.966	0.659	0.966	0.659
OSC	0.935	0.507	0.935	0.507
Supervisory SSTL	0.950	0.681	0.950	0.681
PsyCap	0.877	0.644	0.877	0.644
CS	0.894	0.739	0.894	0.739
Social desirability			0.685	0.306

Note: AVE= average variance extracted; CS=Co-worker Support; CR=composite reliability; GSC=Group-level safety climate; OSC=Organisational-level safety climate; PsyCap=psychological capital; SSTL=Safety Specific Transformational leadership

STRUCTURAL MODEL

A structural model was established and examined to test the hypotheses. Table 4 provides the information on the goodness of fit indices. $\chi 2$ test = 0.000; RMSEA = 0.052; RMR = 0.042; CFI = 0.900; NFI = 0.796; IFI = 0.901; AGFI = 0.723; PNFI = 0.759; PGFI = 0.686; PCFI = 0.858. All these values were higher than their

corresponding thresholds, indicating that the structural model obtained good model fit. Moreover, the total variance explained is adequate for the endogenous variables: $\gamma^2 = 60.6\%$ for the group-level safety climate as show in Figure 2.

Table 4. Test results of goodness-of-fit measures for the structural model

Index name	Measure	Ideal value	Hypothetical model	Evaluation
Absolute fit index	$\chi 2$ test	<0.05	0.000	Excellent
	RMSEA	<0.08	0.052	Excellent
	RMR	<0.05	0.042	Good
Incremental fit index	CFI	>0.9	0.900	Good
	NFI	>0.7	0.796	Excellent
	IFI	>0.9	0.901	Good
	AGFI	>0.7	0.723	Good
Parsimonious fit index	PNFI	>0.5	0.759	Excellent
	PGFI	>0.5	0.686	Excellent
	PCFI	>0.5	0.858	Excellent

Note: AGFI = adjusted goodness-of-fit index; CFI = comparative fit index; IFI = incremental fit index; NFI = normed fit index; PCFI = parsimony comparative fit index; PGFI = parsimony goodness of fit index; RMR= non-root mean square residual; RMSEA = root mean square error of approximation

Direct Effect

The results of 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 would improve with a stronger OSC. The effect of supervisory safety-specific transformational leadership (SSTL) on GSC is significantly positive ($\beta = 0.549$, $p < 0.001$), evidencing H2. The significant effect of co-worker support (CS) on GSC ($\beta = 0.193$, $p < 0.001$) supports H3, suggesting that CS have a positive impact on GSC. The effect of supervisory SSTL on employees' psychological capital (PsyCap) is significantly

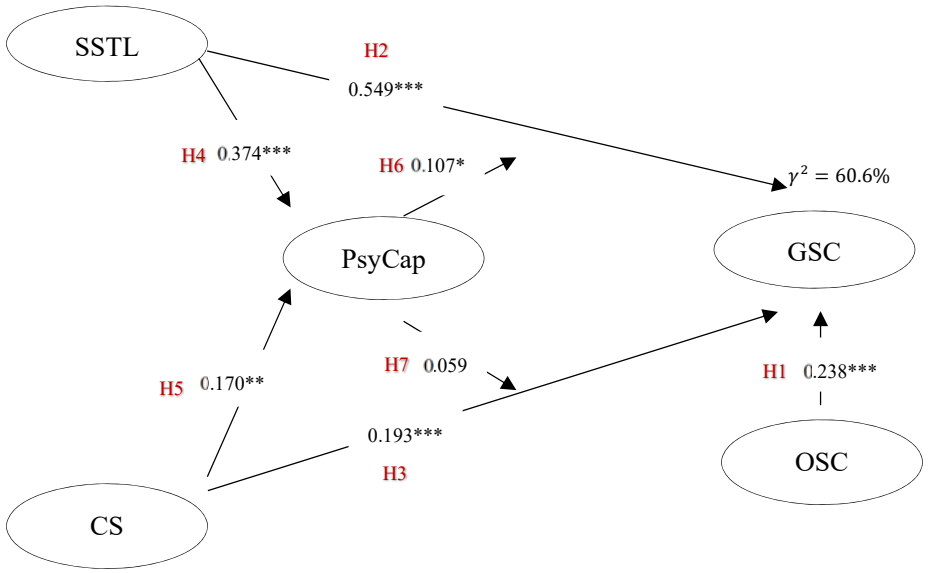
positive ($\beta = 0.374$, $p < 0.001$), supporting H4. The effect of CS on PsyCap ($\beta = 0.170$, $p < 0.05$) supports H5, indicating that there is a significant positive relationship between CS and PsyCap.

Table 5. Test results of the hypotheses

Hypothesis	Beta coefficient	*p*-value	Evaluation
Direct Effect			
H1: OSC→GSC	0.238	<0.001	Accepted
H2: Supervisory SSTL→GSC	0.549	<0.001	Accepted
H3: CS→GSC	0.193	<0.001	Accepted
H4: Supervisory SSTL→PsyCap	0.374	<0.001	Accepted
H5: CS→PsyCap	0.170	< 0.05	Accepted
Moderation Effect			
H6: PsyCap * Supervisory SSTL→GSC	0.107	0.017	Accepted
H7: PsyCap * CS→GSC	0.059	0.185	Rejected

Note: CS=Co-worker Support; GSC=Group-level safety climate; OSC=Organisational-level safety climate; PsyCap=psychological capital; SSTL=Safety Specific Transformational leadership

Fig. 2. Hypothesized model estimation results

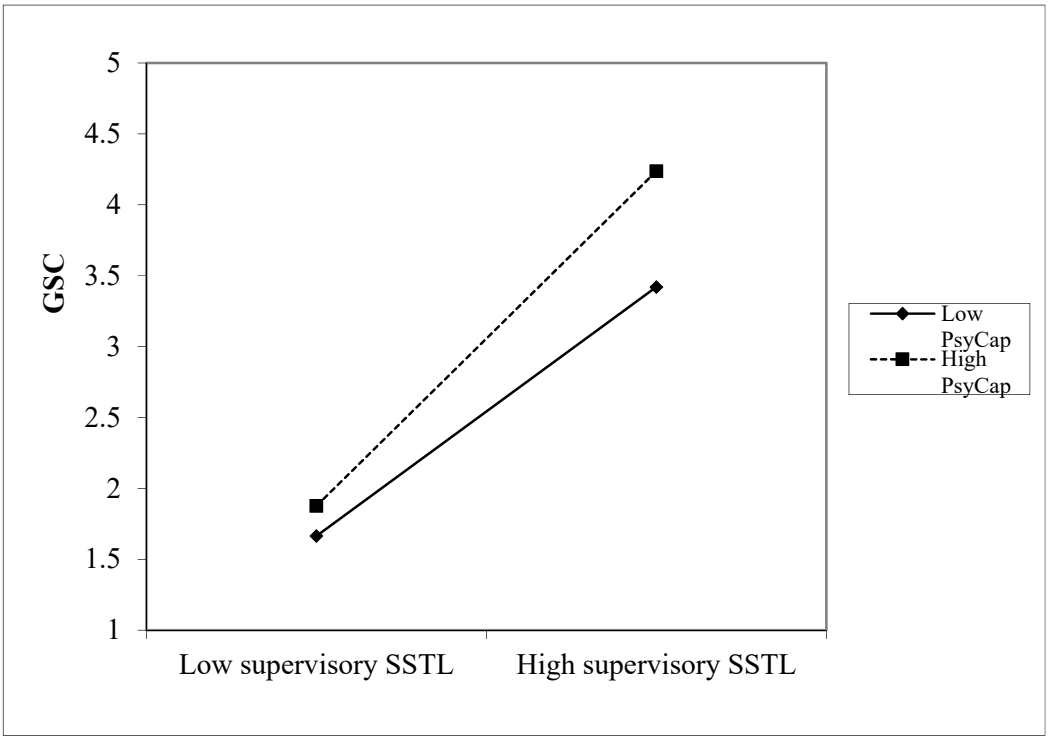


Note: *** p<0.001, **p< 0.01, *p<0.05.

Moderation

The moderation effect measures whether the degree to which a relationship between one variable and another variable would be affected by a third variable. The coefficient of the interaction term (PsyCap * supervisory SSTL) is significantly positive (β = 0.107, p =0.017), indicating that PsyCap strengthens the relationship between supervisory SSTL and GSC. Thus, H6 is supported. To facilitate explicit understanding of how PsyCap moderates the relationship between supervisory SSTL and GSC, the result is graphically shown in Figure 3. As PsyCap increases, the slope of the effect of supervisory SSTL on GSC becomes steeper, indicating PsyCap strengthens the effect of supervisory SSTL on GSC. However, the coefficient of the interaction term (PsyCap * CS) is not significant (β = 0.059, p =0.185), suggesting that PsyCap has no significant moderation effect on the relationship between CS and GSC. Thus, H7 is rejected.

Fig. 3. Moderation effect of psychological capital (PsyCap) on supervisory safety specific transformation leadership (SSTL) and group-level safety climate (GSC).



Note: GSC=Group-level safety climate; PsyCap=psychological capital; SSTL=Safety Specific Transformational leadership

DISCUSSION

Research has revealed that group-level safety climate (GSC) is a stronger predictor than organizational-level climate (OSC) on predicting safety outcome (e.g. Brondino et al., 2012, Prohst, 2015); thus, the present study sought to examine its antecedents and associated influencing mechanisms that could enable construction firms to develop more effective interventions and training programs to enhance GSC. Building on the previous study by Cheung and Zhang (2020) that focused on examining the role of organizational support in improving GSC, this study adds to the

487 body of knowledge by further demonstrating how organizational, group, and
488 individual psychological factors interactively play a role in the dynamics.
489 Specifically, the results of the study confirm that OSC, co-worker support (CS) for
490 safety and supervisory safety-specific transformational leadership (SSTL) directly
491 affect GSC, and that individual psychological capital (PsyCap) moderates the effect of
492 supervisory SSTL on GSC, while CS and supervisory SSTL contribute to the
493 development of individual PsyCap.

494 Aligning with previous studies conducted by Melia et al. (2008) and Lingard et
495 al. (2012), this study found that OSC has a positive association with GSC in the
496 construction context. This result indicates that how safety is positioned at the
497 organisational level shapes how safety is enacted at the group level (Zohar and Luria,
498 2005). The result suggests that safety efforts at multiple organisational levels are
499 required to create a safe workplace environment that is conductive to positive safety-
500 related outcomes.

501 .

502 In addition to organizational factor (i.e. OSC), the present study indicates that
503 group-level factors, i.e. supervisory safety-specific transformational leadership
504 (SSTL) and co-worker support (CS) for safety, are essential for the cultivation of a
505 positive group-level safety climate (GSC). According to Zohar and Luria (2004),
506 safety climate is a social-cognitive construct as it relates to employees' perceptions on
507 the types of role behaviors that are likely to be rewarded and supported through their

experience in different organizational events, which often involve interaction with their supervisors and co-workers. In particular, Zohar and Luria (2004) pointed out that organisational events are episodes from which employees make sense of their environment. Rentsch (1990) defined "sense-making process involves observing organizational events, detecting or abstracting patterns of relationships among the events, and interpreting these events in psychologically meaningful terms" (p.669). For example, if supervisors consistently emphasize safety procedures over production pressures and reward safe work behaviors, employees will perceive that safety is prioritised and expected in their team, and thus they will behave safely to comply with the safety expectation. By the same token, if employees perceive that their co-workers support safe work behaviors, frequently discuss about how to work safely, and care about other's safety, they are more likely to positively respond to the 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 it also discovered that SSTL and CS help to build employees' PsyCap, the individual-level factor that comprises of personal optimism, self-efficacy, hope and resilience. These findings are promising, especially when considering that the knowledge of PsyCap in safety context is at its early stage (Stratman & Youssef-Morgan, 2019) while this study also found PsyCap positive moderately the impact of SSTL on GSC. Knowing the antecedents (i.e. SSTL and CS) of PsyCap could inform our understanding on how to help employees to develop this positive psychological state. From a conceptual and empirical standpoint, the findings imply that the levels

530 of personal PsyCap can be related to employees' contextual factors. For example, by
531 practising SSTL, supervisors tend to: 1) demonstrate a high commitment to safety and
532 setting good safety role models, which would encourage subordinates to believe in
533 positive safety outcomes, resulting in building their optimism in PsyCap; 2) motivate
534 and inspire subordinates to accomplish challenging safety-related tasks, which would
535 reinforce subordinates' belief in their ability to cope with challenging goals, resulting
536 in developing self-efficacy in PsyCap as subordinates become confident that good
537 safety performance can be accomplished, resulting in the development of hope in
538 PsyCap; and 3) provide individualised safety support and mentoring to subordinates,
539 which would develop subordinates' resilience in PsyCap to deal with adversity.
540 Furthermore, these results are aligned with the findings of Luthans et al. (2007) in
541 which they concluded that a supportive organizational climate is essential to develop
542 PsyCap, while the interactions with supervisors and co-workers have a significant
543 impact on how employees perceived organisation climate (Dehring, Von Treuer &
544 Redley, 2018).

545 In addition, with the coefficient of determination (γ^2) equal to 60.6% in this
546 study, it means the hypothesized model explains a substantial degree of variance of
547 GSC. By looking at the direct effects of all independent variables in the model,
548 supervisory SSTL is found to obtain the highest beta coefficient (0.549). The result
549 implies that supervisory SSTL has the strongest impact on GSC compared to other
550 variables in the model. This finding is not completely surprising as the incentives
551 provided by superiors, such as personal attention and recognition, have consistently

552 shown to provide the strongest reinforcement value in organisational culture and
553 policies, exceeding material and social incentives (e.g. co-worker support) (Stajkovic
554 & Luthans, 1997). Zohar and Luria (2003) advocated to implement behavioural safety
555 interventions focusing on supervisors instead of individual workers and found that
556 such interventions increased supervisory safety-oriented interaction significantly,
557 resulting in significant improvements in worker's safety behaviour and safety climate
558 scores.

559 Apart from the significant direct effects found in the study, a significant
560 moderation effect of PsyCap on the relationship between supervisory SSTL and GSC
561 was also revealed. This result is aligned with cognitive theories of perception in which
562 the formation of perception is a function of three classes of variables – the objects or
563 events being perceived, the environment in which perception occurs and the
564 individual doing the perceiving (Gelman and Au, 1996). In this study, GSC is the
565 object being perceived, supervisory SSTL creates the environment in which
566 employees' perceptions occur, and individual with different PsyCap levels doing the
567 perceiving. Specifically, through practising SSTL in daily operation, supervisors
568 constantly send messages to their group members about their high safety expectations,
569 which thus enhances the GSC. Meanwhile, high levels of PsyCap can strengthen this
570 relationship because the greater the individuals' PsyCap, the stronger their ability to
571 implement safety standards and procedures, cope with difficulties in achieving safety
572 goals and conform with supervisory expectations regarding safety (e.g. Eid et al.,

2012; Chen and Chen, 2014; Wang et al., 2018). As a result, PsyCap helps individuals to reinforce the positive influence of supervisory SSTL on cultivating GSC.

In addition to supervisory SSTL that creates the environmental condition in which GSC occurs, this study also examined another environmental attribute, co-worker support (CS) for safety, and investigated whether PsyCap positively moderates the relationship between CS and GSC. However, the moderation effect was not significant. Drawing on the findings in gender studies, the dominant heteronormative masculinist culture in construction (Sang & Powell, 2012) may explain this insignificant interaction effect. Aligned with the gender distribution in the construction industry, this sample data consists of 90.7% male. As mentioned above, the study found that SSTL has a much stronger impact on GSC than CS. This suggested that employees perceive the influence from supervisors is much higher than from their co-workers in formulating of GSC. In addition to the incentive lens used above to explain the phenomena, the dominant culture of masculinity in construction, which prescribes men should tolerate harsh working conditions and be dominant over their peers instead of asking them to help (Lacuone, 2007), could provide another perspective to depict why employees perceive CS as a less important factor to build a safe work environment. Consequently, conforming co-workers' expectation on safety would be at a lower priority. Under the circumstances, employees could be less motivated to utilise their PsyCap, which helps exert greater efforts, to fulfil co-workers' expectation on building a safety workplace.

LIMITATIONS AND FUTURE RESEARCH

Although this study provides some important insights into the mechanism of how organizational, group and individual factors cultivates GSC, it has limitations, that need to be acknowledged. First, the sample data in this study was collected from a single large construction organization with the aim of controlling the confounding effect of intra-organizational differences such as culture and structure. As a result, the findings may not be generalizable to other construction firms of different sizes. Future research should be conducted to test the applicability of the model to other companies with various sizes within the same sector or in different engineering sectors. Validating the research model in different firms and sectors could help unpick the shared patterns of how different organization, group and individual factors affect GSC, as well as differences due to different company sizes or industry sector characteristics. Secondly, because the data of the study was collected in two time points from the same individuals, the relationships among the variables could be confounded by common method bias. Although the longitudinal research design and statistical control on social desirability were carried out to minimize the effects of common method bias, it is recommended that multiple sources can be used for each data point in future studies in order to solve the problem fundamentally. Finally, a limitation relates to the sample representativeness. Like other longitudinal studies, attribution may be an issue as the longitudinal sample could over-represent highly committed employees who care more about the subject matter than others (Neal & Griffin, 2006).

CONCLUSION

Longitudinal studies on examining how organizational, group and individual factors affect group-level safety climate (GSC) are uncommon. The present study was conducted in a 2-year period during which supervisory safety-specific transformational leadership (SSTL) and co-worker support (CS) were measured prior to the measure of psychological capital (PsyCap), organizational-level safety climate (OSC), and GSC. Therefore, the study has contributed to the body of knowledge in terms of providing stronger evidence on the causation relationships and the underlying mechanism than previous cross-sectional studies within the field.

The results of this study have both theoretical and practical implications. Theoretically, the research extends previous studies by examining the influences of multilevel factors on group-level safety climate (GSC) as well as the interactions between the multilevel factors. Particularly, the research is one of the first to examine the role of personal resource, i.e. psychological capital (PsyCap) in the formation of GSC in the construction industry context. The research highlighted the importance of supervisory safety specific transformational leadership (SSTL) and co-worker support (CS) for safety, i.e. they not only positively influence safety climate within workgroups but also contribute to the development of employee PsyCap which in turn enhances the relationship between supervisory SSTL and GSC. The research findings provide evidence for construction organizations to develop useful intervention programs to develop supervisors' SSTL and foster support among group members. Leadership training can be a useful way to improve supervisory SSTL skills. For example, Mullen and Kelloway (2009) demonstrated that providing SSTL training

programs to supervisors are effective in developing supervisory capability in promoting and improving safety in workplaces. Burt et al. (2008) suggested that nurturing a caring attitude among employees helps to develop support within workgroups. They also pointed out that the development of a caring attitude relies on the extent to which employees know about their co-workers and the levels of social interactions among employees. Therefore, construction organizations can consider organizing informal social activities or events as platforms for employees to engage in social interactions with co-workers and acquire knowledge of co-workers so as to strengthen social ties and facilitate the development of a sense of care and support among employees.

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