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Exploring the Multilevel Perception of Safety Climate on Taiwanese Construction Sites

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Abstract: This study investigates multilevel differences in safety climate (SC) perception dimensions between management and laborers on Taiwanese construction sites. With Taiwan's high rate of construction site safety incidents, implementing successful safety strategies requires understanding differences in SC perceptions between management and laborers. This study used a structured SC questionnaire with responses from 74 managers and 261 laborers. The analysis of collected data includes (1) descriptive statistics comparing the selected dimensions; (2) Pearson correlation analysis examining relationships between SC perception dimensions; (3) *t*-test and one-way ANOVA to assess relationships between the respondent's background and SC perception dimensions; and (4) Post-Tukey comparison analysis to compare the SC perception differences between management and laborers. The results indicate that management-level staff show a higher degree of SC perception than laborer-level staff. This level of SC perception varies between individual dimensions. The strongest convergence between the two groups is observed in the dimension of 'workmate care of each other', and the greatest divergence is found in 'risk decision making'. Previous studies regarding SC perception in Taiwan specifically focus on construction workers and neglect the differences in perception between management and laborers. The outcomes of this study contribute to the understanding of multilevel SC perceptions, which can be used in the development of targeted strategies to improve SC on construction sites.

Keywords: construction safety; safety climate perception; safety management; construction site; worker safety

1. Introduction

Construction is one of the most hazardous industries in terms of personal injury [1]. While it only accounts for 7% of global employment, it accounts for 30–40% of overall workplace injuries [2] with corresponding annual economic losses as high as US$120 billion [3]. In Taiwan, construction accounts for 10% of the total employment, but accounts for 45~55% of all fatal occupation accidents [4]. Both industry and researchers have devoted considerable effort to reducing worksite safety accident rates by reducing the incidence of unsafe behavior and improving safety performance [5,6]. High incidences of construction accidents are attributable to a lack of adequate safety precautions and a poor Safety Climate (SC) [7]. In this paper, SC is defined as beliefs, awareness and values held by all project stakeholders regarding worksite safety. A positive SC can promote improved safety practices, where SC is a key indicator of overall safety performance, which directly reflects organizational safety management performance, indicating potential deficiencies in need of improvement [8,9]. The Taiwanese construction industry experiences a high rate of serious incidents involving significant injuries and fatalities [10], which have serious social and economic impacts. The purpose of this study is to examine the multilevel SC perception differences held by management and laborers on Taiwanese construction sites to inform initiatives aimed at improving safety outcomes in the construction industry.

Conceptually, SC is best considered a multilevel construct with significant differences amongst organizational subgroups. Furthermore, these subgroups can be considered as distinct constructs with corresponding measurement scales [11]. Ensuring an effective understanding of construction site SC requires establishing comprehensive and specific SC perception patterns amongst organizational subgroups and clarifying the corresponding internal relationships among multiple SC dimensions. Building on SC, the term SC perception is defined as the perception of the current SC by construction personnel and is influenced by characteristics specific to their professional status, work experience and personal background. In the current body of literature, few studies have focused on understanding SC perception among construction organizational groups and subgroups, both internationally and within the Taiwanese construction industry. Institutional and professional cultures differ among various countries and regions. These national cultural values can have a profound influence on workplace practices and safety values [12], thus limiting the generalization of current international studies to the Taiwanese context. Therefore, this study focuses on exploring SC perceptions as they apply to the construction industry in Taiwan with the intent to build on the current knowledge gaps regarding organizational SC perceptions on construction sites. Understanding SC perception patterns for construction workers in Taiwan provides a foundation for designing targeted strategies to improve construction site safety performance and warrants further investigation due to a high number of construction site incidents. An obstacle is that a consensus on SC dimensions is still lacking, along with a clear understanding of the relationships and interactions between different dimensions. Furthermore, the existing literature on multilevel SC perception differences amongst construction personnel still suffers from several shortcomings that need to be resolved.

1.1. Previous Research

1.1.1. Concepts of Safety Climate

SC can be defined as a unified set of cognitions related to an organization's safety dimensions [13]. SC reflects employees' shared perceptions about the relative importance of safe conduct in their occupational behavior in terms of safety policies, procedures, and practices. SC is often confused with safety culture (SU); several studies have sought to differentiate SC and SU as distinct but closely related concepts [14]. Many researchers have constructed definitions for SU, with the common theme of how people think or behave in relation to safety [15]. For this study, SU is considered the product of individual and group values, attitudes, concepts, abilities, behaviors, and management styles. Culture reflects deeper values and assumptions, while climate refers to shared perceptions among a relatively homogeneous group [16]. O'Connor et al. [17] believed that SC can provide a "snapshot" of an organization's SU. Culture is a representation of an organization's enduring characteristics, comparable to its personality. SU reflects fundamental values, norms, assumptions, and expectations, which are formed by societal culture [18]. The reference to climate, on the other hand, is thought to represent a more visible manifestation of the culture. Positive perceptions of safety will improve the likelihood of safe behavior, thus reducing accidents [19].

SU is a top-down approach to workplace safety management and is said to be positive if the corporate culture adequately prioritizes safe work practices [14]. Safety climate is related to the perception and attitudes of workers towards worksite safety, and organizational SU can be assessed in terms of workplace SC, which also covers crucial safety-related variables such as training, management organization, management attitudes toward safety, the role of worksite safety in management advancement, supervisor behavior, safety equipment, and perceived likelihood of injury [20]. Teo and Feng [21] found that SC exerts psychological, situational/environmental, and behavioral influences on SU. The current body of literature shows that SC assessments can be used reliably to predict the overall quality of an organization's SU.

1.1.2. Safety Climate Research in Construction

Dedobbeleer and Béland [22] conducted the first investigation exploring SC in the construction industry. Since then, several related studies have been undertaken to explore new research directions to improve the understanding of construction SC. According to Shen et al. [23], prior research on SC in the construction industry has focused on the psychometric measurement issues of psychological SC and the factor structure of SC scales and the predictive relationship between SC and related outcomes. They conclude that there remains a need for further research on the development of psychological SC. Shen et al. [24] created a conceptual framework for the development of psychological SC. The results indicated that management can leverage off structural, perceptual, interactive, and cultural aspects to promote the development of the desired psychological SC. They later examined factors promoting the development of a psychological SC through an operationalization of SC at the individual level to form a fundamental component of SC at higher levels. The results provide managers with three paths to forming a psychological SC: the client's proactive involvement in safety management, a safe workplace created by the project team, and the transformation of communication between supervisors and labor about safety related issues.

Previous research has identified a wide range of SC factors, which link SC with safety performance. Choudhry et al. [5] surveyed SC conditions on Hong Kong construction sites to determine structural factors and assess the association between SC and perceived safety performance. Zhou et al. [25] conducted a longitudinal assessment of SC factor structures and SC improvements in a construction company in China over the course of three years, finding statistically significant improvement in all four SC factors, with safety regulations and training being the most effective means of improvement, and thus recommending an increase in the frequency and strength of safety training to improve laborer's attitudes towards safety measures.

Lingard et al. [26] investigated group-level SC in the Australian construction industry. They constructed a SC framework involving multiple dimensions, which included supervisor safety leadership, supervisor safety response, coworker safety response, co-worker ideal safety and co-worker actual safety. These factors were found to effectively regulate workers' safety behavior and improve organizational safety performance. Additionally, Lingard et al. [6] explored the relationship between SC cognitions and injury frequency rates. They found that perception of supervisor safety expectations fully mediated the relationship between cognitions of top management commitment to safety and the workgroup injury frequency rate. Through multi-wave SC surveys of four projects in New Zealand involving processing plant construction, Zhang et al. [27] used a longitudinal approach to measure the SC of construction projects and examine the relationship between SC and project completion objectives in dynamic construction project environments. The results indicate that construction project management structures need to continuously prioritize the importance of worker safety, even in the face of delivery pressures. Zahoor et al. [28] investigated the relationship between SC and safety performance in multi-story building construction in Pakistan and sought to identify SC factors that increase safety performance.

A multitude of different dimensions have been proposed for measuring and assessing the SC of work environments. A review of literature on SC measures (Table 1) found that management commitment (8) is the most frequently mentioned dimension, followed by communication (4), safety training (4), risk decision-making (4), safety attitude (3) and workmate care of each other (3).

Dedobbeleer and Béland [22] noted that studies of SC in construction field are mostly concerned with SC measurement at construction sites. Their study used a self-administered questionnaire, and a two-factor model was verified to be a reliable fit for SC measurement in construction sites. Gao et al. [29] conducted a comprehensive review of SC measurement tools in the construction industry. Based on the review of 36 SC related papers, they found that inductive methods are frequently used for SC measurement due to a lack of a unified methodology. In terms of the survey instruments used in research studies, several prominent emergent themes within SC literature have been observed [30]. The most common themes are measures of rules and procedures, and management, with other themes of importance being impact of work environment, worker involvement and communications. The management level is commonly where safety expectations for an organization are set; however, the laborer level is where the outcomes of the safety expectations are realized. Measuring at the management alone in construction context is of limited value due to the complexities of multiple tiers of management and the separation between organizational management and laborers [30]. Therefore, in this study the perceptions of management and laborers are captured in the survey to explore the potential differences in a multilevel construct.

Table 1. Summary of safety climate dimensions in construction.

No. of Dimensions	Dimensions Included	References
2	Management commitment to safety; worker involvement in safety	Dedobbeleer and Béland (1991) [22]
6	Communication and support, adequacy of procedures, work pressure, personal protective equipment, relationships, safety rules	Glendon and Litherland (2001) [31]
10	Safety attitudes and management commitment, safety consultation and safety training, supervisor role and workmate role, risk taking behavior, safety resources, appraisal of safety procedure and work risk, improper safety procedure, worker involvement, workmate influence, competence	Mohamed (2003) [14]
10	Safety attitude and management commitment, safety consultation and safety training, supervisor role and workmate role, risk taking behavior, safety resources, appraisal of safety procedure and work risk, improper safety procedure, worker involvement, workmate influence, competence	Fang et al. (2006) [32]
2	Management commitment and employee involvement, inappropriate safety procedures and work practices	Choudhry et al. (2009) [5]
7	Management safety priority, commitment and competence; management safety empowerment; management safety regulations; worker safety commitment; worker safety priority and risk non-acceptance; safety communication, learning, and trust in co-worker safety competence, worker trust in the efficacy of safety systems	Kines et al. (2011) [33]
4	Management commitment to safety, supervisor support for safety, safety practices, work pressure	Cigularov et al. (2013) [34]
4	Perceptions of the extent to which safety is prioritized over other objectives, perceptions of manager commitment to safety (at both client and contractor levels), perceptions of first level supervisor safety behavior; perceptions of the quality of safety communication within construction projects	Lingard et al. (2013) [9]
4	Safety priority, safety supervision, training and communication, safety rules and procedures, safety involvement	Wu et al. (2015) [35]

Safety climate measurement is usually performed as follows: (1) Design a questionnaire for data collection in reference to previous relevant studies; (2) analyze questionnaire responses to obtain the SC dimensions (factor framework); (3) perform in-depth analysis targeted at SC dimensions. Typically, dimension classification is the key premise in terms of SC measurement. It is also a key criterion for determining measurement results. Several studies have classified SC facets using a vast range of dimensions. The prevalent disparity and divergence in the identification of SC dimensions has produced confusion and inconvenience for both construction researchers and practitioners seeking to implement programs for SC measurement [35]. A systematic classification of existing SC dimensions is needed, particularly to account for regional variation in construction cultures. Newaz et al. [36] developed a five-factor model to assess SC characteristics in the construction industry. The model showed little regularity in factor significance. However, management commitment to the safety role of the supervisor, workers' engagement in safety initiatives and overall group SC appear to have the highest mutual importance throughout the studies reviewed.

Currently, there is no unified model for measurement of SC perception [30]. Zohar [37] developed an eight-factor model based on a survey of laborers in Israel. This was later simplified to a three-factor model, including management attitudes, management actions, and employee level of risk. Fang et al. [32] suggested a 15-factor model for SC measurement based on the results of factor analysis. Kines et al. [33] created a 50-item/seven-dimension Nordic questionnaire (NOSACQ-50) that reliably measured SC, and predicted safety motivation, perceived safety level, and self-rated safety behavior. Lingard et al. [9] used a multilevel approach for measuring SC based on the "core dimensions" identified by Flin et al. [38]. Wu et al. [35] identified the core and specific dimensions of SC along with the four most commonly used dimensions, and used this as the basis for establishing a core dimension structure of SC. In a review of construction projects from around the world, Gao et al. [39] found that nationality, religious beliefs, and employment type can significantly impact SC perceptions.

1.2. Current Research Gaps

Construction SC is typically classified into multiple dimensions with notable inconsistency between dimensions. The only consensus on dimensions appears to be with management commitment to safety [40]. Furthermore, existing studies have only focused on issues related to dimension classification, but largely neglect the relationship between different dimensions. Few studies have undertaken empirical investigations of the internal structure of SC or examined the associations between different common dimensions. Wu et al. [35] defined core and specific SC dimensions and examined associations between them. In other words, existing SC research into the interrelationships among various aspects is clearly insufficient. More specifically, there is a lack of systematic studies regarding SC perceptions amongst the various levels and classifications of construction personnel.

Some studies have pointed out that differences may exist among an organization's personnel in terms of SC perception differences due to variation in functional roles. According to Glendon and Litherland [31], there is a substantial gap in the SC understanding of road construction workers in various functional areas (i.e., construction and maintenance). Gillen et al. [41] investigated the workplace SC perception of construction workers who had sustained jobsite injuries, finding significant differences between union and non-union workers. Okoye and Aderibigbe [42] found that casual and permanent construction workers differed significantly in terms of onsite safety behavior. The above literature limits their discussions and findings within the same position levels. Marin et al. [43] focused on the SC of Hispanic construction workers, contractors, and supervisors, finding that the SC scores of laborers were significantly lower, and SC was significantly correlated to certain personal characteristics and individual safety behavior; however, the relationship between different dimensions of SC was not analyzed in any great detail. The current literature illustrates that many SC studies have limitations and in understanding difference in perceptions between construction project managers and laborers.

2. Materials and Methods

Targeted questionnaires are widely used instruments in construction safety research due to the ability to efficiently capture a multitude of individual observations of performance against SC perception measure. For measuring SC, survey instruments focus on measuring a set of themes often derived from existing safety literature [30]. A structured format using a Likert-type scale was considered the most suitable for this study, due to the ability to undertake detailed statistical analysis of the responses. With a focus on multilevel perception of SC on construction sites, the target respondents for the questionnaire were Taiwanese laborers and managers with current experience working on construction sites in Taiwan. Capturing a representative sample of the wider Taiwanese construction industry was achieved by distributing questionnaires to construction companies actively operating in Taiwan across all counties. To ensure accurate responses, the questionnaire answers were primarily obtained via a face-to-face interview and where an interview was not practical responses were returned via email. Due to the large geographical area of the study, the questionnaire was first introduced and explained to managers prior to being forwarded to laborers. The laborers were then allowed to complete the questionnaire anonymously and return it directly to the authors. Participation in the study for all respondents was entirely voluntary. Managers were also entrusted with providing a description of the questionnaire and providing initial responses to questions raised by the laborers. Any questions that could not be easily answered by managers or where respondents wanted an impartial response the authors were available to respond personally via phone or email.

According to Taiwan's Construction Industry Act (2018), construction enterprises are classified into the following categories: specialized construction enterprises (SCE) and civil engineering contractors (CEC). General construction business (GCB) is categorized into three grades of A, B and C. CECs are licensed at the municipal or county level to perform small-scale construction and renovation jobs. Generally, GCBs are larger than CECs and have greater experience and expertise. In addition, any construction site that requires more than 30 workers for daily construction works is required to employ at least one certified safety engineer. The construction staff of GCBs were one of the major targets of questionnaire developed for this study.

The two-part questionnaire was developed to explore the SC perception differences between construction site management and laborer levels. The first part of the questionnaire collects relevant personal information from survey respondents to screen eligibility. The second part consists of 38 items classified into five dimensions, which were defined in accordance with the content of 38 items. The five dimensions include: Safety attitude (SAT), safety training & policies (STP), risk decision-making (RDM), safety commitment & communication (SMM), and workmate mutual care (WMC).

The construct of the questionnaire was validated through review by five certified construction safety engineers and their feedback was incorporated into the finalized pre-test questionnaire. Five out of 38 items were deleted because their means failed to exceed 3.4 (a threshold suggested by professional practitioners) and one item was revised to improve clarity. Table 2 displays the final questionnaire, which includes five dimensions and 33 assessment items (AIs).

Table 2. The final questionnaire's assessment items (AI).

Dimension	Assessment Items (AIs)
Safety Attitude (SAT)	AI_{01} Many unsafe behaviors are longstanding habits
	AI_{02} Work productivity is more important than job safety
	AI_{03} Improvement is still required to address worksite safety issues
	AI_{04} All actions we can take to improve worksite safety have been completed
	AI_{05} Active use of safety procedures prevents accidents
	AI_{06} I understand all safety requirements and safe work procedures applicable to my job duties
	AI_{07}: Not all colleagues comply fully with safety procedures or regulations
Safety Training & Policies (STP)	AI_{08}: My company actively prioritizes safety and ascribes a high level of importance to safety training programs
	AI_{09}: My company provides adequate safety resources
	AI_{10}: Safety training is a real help for my work
	AI_{11}: My company is active in identifying unsafe behaviors to make improvements
	AI_{12}: My company conducts regular worksite inspections to prevent accidents
	AI_{13}: My company has too many safety procedures or regulations
	AI_{14}: My company provides inconsistent safety training, procedures, or inconsistent safety requirements
Risk Decision Making (RDM)	AI_{15}: I sometimes feel unsure about safe work practices
	AI_{16}: Some colleagues are simply unaware of safety risks at work
	AI_{17}: Some safety procedures or regulations are difficult to follow
	AI_{18}: Some worksite conditions can cause unsafe work
	AI_{19}: Practical limitations prevent the full implementation of some safety procedures and practices in the worksite
	AI_{20}: Some work simply cannot be completed in a perfectly safe way
	AI_{21}: I occasionally must take safety risks to complete my work
Safety Commitment and communication (SMM)	AI_{22}: Multiple levels of subcontractors is a key factor in communication difficulties, contributing to an increase in the potential for worksite accidents
	AI_{23}: My company provides a healthy and safe working environment
	AI_{24}: My company genuinely reviews and evaluates employee recommendations for enhancing worksite safety
	AI_{25}: My company actively solicits and reviews safety advice and implements, improvements
	AI_{26}: My company pays attention to safety, not just to official inspections
	AI_{27}: My supervisor/colleagues act to prevent unsafe work practices
	AI_{28}: Company managers will inform workers of hazards that may occur in the workplace
Workmate Mutual Care (WMC)	AI_{29}: When working, I pay attention to the working safety of my colleagues
	AI_{30}: My colleagues feel upset with failure to comply with safety procedures or regulations
	AI_{31}: All colleagues are familiar with safety use of equipment and their location
	AI_{32}: In the workplace, some colleagues do not comply with safe work practices
	AI_{33}: Some colleagues will feel disturbed by colleagues working under unsafe conditions

2.1. Sample Analysis

This data collected from the study was processed using SPSS V18 statistical package. Questionnaires were distributed to managers (122) and laborers (435). The return rate was 71.1%, with a validity rate of 84.6% for a total of 335 valid questionnaires. Of the valid responses, 74 were from managers and 261 were from laborers. Approximately 94% (313/335) of valid respondents identified as male. Respondents educational levels covered both tertiary and secondary schooling levels. Referring to Figure 1, 77% had completed tertiary education, of which 24% of all respondents were junior college (JC) graduates and the remaining 53% held college or above qualifications. The responses received showed that of the laborers surveyed, 11 were under 26 years old, while 8 were over 54 years old, and 60% of all respondents fall in the age range of 33–46. The diverse backgrounds of the respondents provide a good sample of the managers and laborers employed in the Taiwanese construction industry.

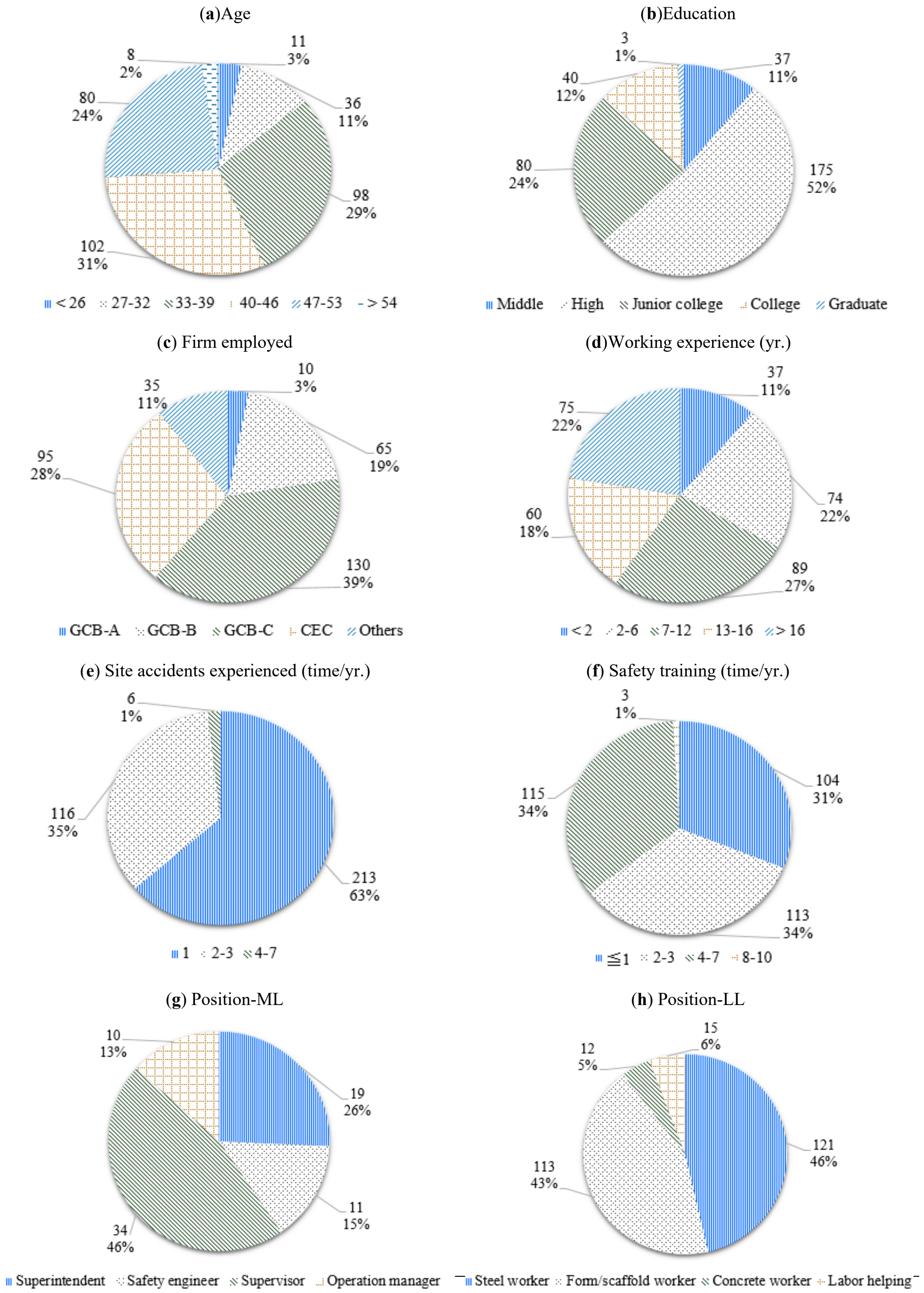

Figure 1. The demographic and background data for questionnaire respondents. (**a**) Age distribution (**b**) highest educational level obtained distribution (**c**) Firm type employed distribution, employment categories are civil engineering contractors (CEC) and General construction business (GCB) which is categorized into three grades of A, B and C. (**d**) Years of work experience in the construction industry distribution (**e**) Annual site accidents experienced distribution (**f**) Safety training events attended distribution (**g**) Distribution of Positions—management level (ML) (**h**) Distribution of Positions—laborer level (LL).

About two-thirds of respondents work for GCBs, with most of the remainder working for CECs. Among management-level respondents, 34 were supervising engineers (10.1%). Among laborer-level respondents, more than two-thirds of respondents reported at least six years' construction work experience. The data also showed that over 35% of respondents reported experiencing 2–3 workplace accidents annually. One-third of respondents reported attending 2–3 safety training events annually. Nearly one-third reported only attending a single safety training event each year. Of the respondents, 121 were steel work laborers representing 36.1% of all respondents and 113 were form/scaffold laborers, representing 33.7% of all respondents. According to Cheng and Lin [44], steel/formwork/scaffold laborers in Taiwan are ranked as the top three highest risk trades in the Taiwanese construction industry. Therefore, this study focused on the three types of skilled steel work laborers for research data collection.

2.2. Reliability and Validity Analysis

The term "Reliability" refers to the internal consistency and stability of test results and is most frequently expressed in terms of Cronbach's α, with a value exceeding 0.7, indicating a high degree of reliability [45] and is considered satisfactory for further analysis [46]. As shown in Table 3, α values for four of the five dimensions in this study exceed 0.7, indicating an acceptable degree of reliability. Since the questionnaire's respondents are mainly project managers and construction workers, the individual dimension reliability of 0.653 for WMC is considered moderately reliable [45]; therefore, the dimension of WMC is retained for further analysis.

Table 3. Safety climate reliability analysis results.

Dimension	Cronbach'α		
	Manager	Laborer	Total
Safety Attitude (SAT)	0.748	0.697	0.750
Safety Training & Policies (STP)	0.710	0.708	0.720
Risk Decision Making (RDM)	0.665	0.656	0.786
Safety Commitment and Communication (SMM)	0.733	0.680	0.725
Workmate Mutual Care (WMC)	0.682	0.634	0.653

Note: $0.9 > \alpha \geq 0.7$ (high reliability), $0.7 > \alpha \geq 0.5$ (moderate reliability) (Hinton et al., 2004) [43].

3. Results

3.1. Descriptive Analysis

Table 4 provides a summary of the data collected through the surveys on a 5-point Likert scale. The AI average represents respondent opinions, with higher scores indicating a higher degree of recognition, and smaller standard deviations (SD) indicate higher consistency of opinion among respondents. In Table 4, the average assessment dimension (AD) score for managers in all dimensions is higher than that for workers (3.74 vs. 3.20). The largest gap exists in the RDM dimension (a gap of 1.02), suggesting a considerable difference between how management and labor levels view the effective implementation of safety measures in construction sites. The smallest average difference can be found in the WMC dimension (with a gap of 0.23), showing a strong similarity in their respective views of mutual worksite monitoring of co-workers.

Table 4. Summary of the averaged values, standard distribution and ranks for the survey responses for the Assessment Dimensions (ADs) and Assessment Items (AIs).

ADs	AIs	Management (N = 74)				Laborer (N = 261)				Overall (N = 335)			Overall $Rank_{AD}$
		Avg.	SD	$Rank_{AI}$	$Rank_{AD}$	Avg.	SD	$Rank_{AI}$	$Rank_{AD}$	Avg.	SD	$Rank_{AI}$	
SAT	AI_{01}	4.03	0.793	5	1	3.55	0.852	10	4	3.65	0.861	7	4
	AI_{02}	3.72	0.785	20		2.95	0.816	23		3.12	0.869	23	
	AI_{03}	3.85	0.902	9		3.69	0.846	2		3.72	0.860	2	
	AI_{04}	4.09	0.743	2		2.20	0.750	33		2.62	1.085	33	
	AI_{05}	3.80	0.776	13		3.64	0.828	4		3.67	0.819	3	
	AI_{06}	4.11	0.769	1		3.46	0.815	14		3.60	0.848	10	
	AI_{07}	3.57	0.861	25		3.10	0.833	22		3.20	0.861	22	
	Mean	3.88				3.23				3.37			
STP	AI_{08}	4.09	0.814	2	5	3.67	0.822	3	2	3.76	0.838	1	3
	AI_{09}	3.80	0.811	13		3.54	0.796	11		3.59	0.806	11	
	AI_{10}	3.73	0.969	18		3.53	0.938	12		3.58	0.947	12	
	AI_{11}	3.50	0.798	30		3.70	0.884	1		3.65	0.868	7	
	AI_{12}	3.51	0.880	28		3.59	0.844	8		3.57	0.851	14	
	AI_{13}	3.54	0.814	27		2.50	0.821	29		2.73	0.926	29	
	AI_{14}	3.50	0.880	30		2.63	0.861	26		2.82	0.937	27	
	Mean	3.67				3.31				3.39			
RDM	AI_{15}	3.65	0.766	22	4	2.67	0.850	25	5	2.88	0.926	25	5
	AI_{16}	3.82	0.783	12		3.44	0.921	15		3.53	0.905	15	
	AI_{17}	3.74	0.684	17		2.55	0.990	28		2.81	1.054	28	
	AI_{18}	3.55	0.894	26		2.49	0.987	30		2.73	1.061	29	
	AI_{19}	3.59	0.935	23		2.44	0.989	32		2.70	1.087	32	
	AI_{20}	3.58	1.007	24		2.49	0.983	30		2.73	1.086	29	
	AI_{21}	3.89	0.820	8		2.59	0.971	27		2.87	1.084	26	
	Mean	3.69				2.67				2.89			
SMM	AI_{22}	3.42	0.891	33	2	2.86	0.976	24	3	2.98	0.985	24	2
	AI_{23}	3.77	0.713	15		3.62	0.835	7		3.66	0.811	6	
	AI_{24}	3.49	1.113	32		3.26	0.820	19		3.31	0.896	21	
	AI_{25}	4.05	0.890	4		3.15	0.860	21		3.35	0.944	20	
	AI_{26}	3.92	0.736	7		3.25	0.916	20		3.39	0.922	18	
	AI_{27}	3.73	0.833	18		3.38	0.821	17		3.45	0.835	17	
	AI_{28}	3.97	0.827	6		3.58	0.845	8		3.67	0.855	3	
	Mean	3.76				3.30				3.40			
WMC	AI_{29}	3.76	0.962	16	3	3.64	0.836	4	1	3.67	0.866	3	1
	AI_{30}	3.84	0.828	10		3.51	0.630	13		3.58	0.691	12	
	AI_{31}	3.51	1.088	28		3.64	0.775	4		3.61	0.854	9	
	AI_{32}	3.84	0.828	10		3.42	0.768	16		3.51	0.800	16	
	AI_{33}	3.68	0.908	21		3.30	0.862	18		3.39	0.885	18	
	Mean	3.73				3.50				3.55			
Overall Mean		3.74				3.20				3.32			

Note: Safety Attitude (SAT), Safety Training & Policies (STP), Risk Decision Making (RDM), Safety Commitment and Communication (SMM), Workmate Mutual Care (WMC).

Among the 33 AIs for management level SC perception, the strongest recognition levels were found in AI_{06} 'I understand all safety requirements and safe work procedures applicable to my job duties' (4.11), AI_{04} 'All actions we can take to improve worksite safety have been completed' (4.09), and AI_{08} 'My company actively prioritizes safety and ascribes a high level of importance to safety training programs' (4.09). Of the laborer level SC perception AIs, the strongest recognition level was associated with AI_{11} 'My company is active in identifying unsafe behaviors to make improvements' (3.70), AI_{03} 'Improvement is still required to address worksite safety issues' (3.69), and AI_{08} 'My company actively prioritizes safety and ascribes a high level of importance to safety training programs' (3.67), suggesting that construction workers have a high degree of respect for the professionalism of worksite managers.

While for the management level SC perception, the weakest recognition was found in AI_{11} 'My company is active in identifying unsafe behaviors to make improvements' (3.50), AI_{14} 'My company provides inconsistent safety training, procedures, or inconsistent safety requirements' (3.50), AI_{24} 'My company genuinely reviews and evaluates employee recommendations for enhancing worksite safety' (3.49), and AI_{22} 'Multiple levels of subcontractors is a key factor in communication difficulties', 'contributing to an increase in the potential for worksite accidents' (3.42). For the laborer level SC perception AIs, the lowest degree of recognition was found for AI_{18} 'The general worksite environment leads to unsafe work' (2.49), AI_{20} 'Some work simply cannot be completed in a perfectly safe way' (2.49), AI_{19} 'Practical limitations prevent the full implementation of some safety procedures and practices in the worksite' (2.44) and AI_{04} 'All actions we can take to improve worksite safety have been completed' (2.20), suggesting that established safety regulations are not widely enforced or are not perceived as adequate. This indicates that managers can execute most of their responsibilities well, and that contractors focus on safety, but are considerably less focused on the quality of safety related communication or safety specific training.

Of the 33 AIs, the items showing the strongest recognition included AI_{08} 'My company actively prioritizes safety and ascribes a high level of importance to safety training programs' (3.76), AI_{03} 'Improvement is still required to address worksite safety issues' (3.72), AI_{05} 'Active use of safety procedures prevents accidents' (3.67), while those with the lowest recognition were AI_{19} 'Practical limitations prevent the full implementation of some safety procedures and practices in the worksite' (2.70) and AI_{04} 'All actions we can take to improve worksite safety have been completed' (2.62). It can be concluded that construction sites suffer from problems enforcing safety requirements, despite prominent safety procedures and frequent safety training events. In addition, only one (RDM) of the five dimensions features a strong degree of commonality between management and laborer viewpoints. Subsequently, clearly divergent perspectives exist regarding the importance of the other four dimensions.

3.2. Pearson Correlation Analysis

Shown in Table 5, positive correlations and statistical significance exist between SAT and STP, RDM, SMM, and WMC. The significance of the results supports the view that organizations in which management effectively disseminates safety knowledge and display positive attitudes towards safety tend to have safer work practices. The dimension STP is positively shows a statistically significant association with RDM (p = 0.032), SMM (p = 0.025), and WMC (p = 0.000), indicating that effective training and policies have a role in improving the safety cognition of individual workers to enhance RDM or workmate care and communications. Interestingly, no significant correlation was found between RDM and WMC (p = 0.359) indicating that, individuals with risk management experience may not have strong influence over the care of other worker's safety.

Table 5. Pearson correlation matrix comparing the survey results for the five safety assessment dimensions.

Dim.	Safety Attitude (SAT)	Safety Training & Policies (STP)	Risk Decision Making (RDM)	Safety Commitment and Communication (SMM)	Workmate Mutual Care (WMC)
Safety Attitude (SAT)	1				
Safety Training & Policies (STP)	0.176 ** (0.001) #	1			
Risk Decision Making (RDM)	0.246 ** (0.000) #	0.117 * (0.032) #	1		
Safety Commitment and Communication (SMM)	0.165 ** (0.002) #	0.122 * (0.025) #	0.314 ** (0.000) #	1	
Workmate Mutual Care (WMC)	0.109 * (0.046) #	0.257 ** (0.000) #	0.050 (0.359) #	0.101 (0.066) #	1

Note: # p value (2-tailed); *significant at $p < 0.05$; ** significant at $p < 0.01$.

These results support the principle that positive safety attitudes, training programs, and policies all facilitate the development of a positive SC within an organization. However, no significant correlation was found between RDM and WMC as well as between SMM and WMC, which suggests that, raising awareness of good safety practices among individual workers alone, may not raise overall safety performance. Enhancing safe working conditions requires instituting strong safety awareness among workers through targeted training programs, along with effective policies and management systems.

3.3. T-Test and One-Way ANOVA

The results for the T Tests and One-way ANOVA shown in Table 6 and the corresponding p values, indicate that respondent age has a significant influence on SAT, RDM, and overall SC, but not for STP, SMM, and WMC, respectively. Respondents across different age's show significantly different safety attitudes, RDM, as well as overall SC. Results also show educational background exerts a strong influence on SAT, STP, RDM, and overall SC, but no influence on SMM and WMC was observed. The data shows that gender and marital status have no significant impact on SAT, STP, RDM, SMM, WMC. Contrary to previous studies on factors influencing SC [32], the data in this study shows marital status has no influence on the overall SC of construction workers. Company type (i.e., CEC/GCB) was found to have a strong impact on SAT, STP, RDM, and overall SC, which suggest different types of companies present different attitudes towards worksite safety, have varying success in the application of safety training and policies to ensure worker safety, as well as varying RDM processes.

Table 6. The results of the difference analysis of the respondents' background attributes for each of the safety assessment dimensions.

Respondent's Background	SAT	STP	RDM	SMM	WMC	Overall SCP
	t/F (p)	t/F (p)	t/F (p)	t/F (p)	t/F (p)	t/F (p)
Gender	0.261 (0.610)	3.439 (0.065)	0.001 (0.980)	0.003 (0.958)	2.941 (0.087)	0.741 (0.390)
Age	3.084 * (0.010)	0.589 (0.708)	2.851 * (0.016)	2.093 (0.066)	1.314 (0.258)	3.247 * (0.007)
Education	2.800 * (0.040)	4.541 * (0.004)	6.248 * (0.000)	2.519 (0.058)	1.439 (0.231)	9.259 * (0.000)
Marital status	1.699 (0.185)	0.369 (0.692)	0.440 (0.644)	0.411 (0.663)	0.421 (0.657)	0.354 (0.702)
Firm employed	4.125 * (0.003)	4.926 * (0.001)	7.970 * (0.000)	1.431 (0.223)	1.504 (0.201)	10.388 * (0.000)
Position level	101.993 * (0.000)	27.800 * (0.000)	211.895 * (0.000)	47.021 * (0.000)	10.365 * (0.001)	312.418 * (0.000)
Working experience	2.843 * (0.024)	1.864 (0.116)	2.580 * (0.037)	1.241 (0.293)	1.887 (0.112)	3.093 * (0.016)
Site accidents experienced	6.037 * (0.003)	5.185 * (0.006)	4.053 * (0.018)	0.154 (0.857)	0.573 (0.564)	5.115 * (0.006)
Safety training	5.110 * (0.002)	4.749 * (0.003)	4.753 * (0.003)	1.159 (0.326)	1.096 (0.351)	7.215 * (0.000)

Note: * Average difference is significant at $p = 0.05$.

As was found with workers age, length of working experience was also found to have a significant impact on SAT, RMD, and overall SC, but not on STP, SMM, and WMC. Previous experience of worksite accidents exerted a significant influence on SAT, STP, RMD, and overall SC, but not SMM and WMC. This result indicates that construction workers who have experienced worksite accidents tend to be more cognizant of influencing factors such a risk management and attitude towards worksite safety. Frequency of safety training events shows a similar pattern to previous experience of worksite accidents, with frequency of safety trainings strongly impacting SAT, STP, RDM, and overall SC, but no significant impact was observed on SMM and WMC. Experience and training have both shown similar influences on personnel's safety attitude and RDM. Additionally, Table 6 also shows a significant difference between respondents from different levels regarding all dimensions (SAT, STP, RDM SMM, WMC, and overall SC). Furthermore, position level was the only background factor that showed a significance impact on WMC.

3.4. Discrepancy Analysis

Table 7 shows the SC perception comparison between management and laborers specifically engaged in steel, formwork, and scaffolding works. The data presented reveals that attitudes towards work safety dimensions differ significantly between management and laborers in these high-risk construction roles. In the SAT dimension, the safety attitude of worksite supervisors differed significantly from that of steel workers, formwork workers and scaffolding workers, although similar safety trainings and policies are implemented. In terms of RDM, managers also differed significantly from laborers in terms of risk assessment regarding construction site issues. Differences in the SMM dimension were found for 'emphasis on safety issues' and 'communication between supervisors' on the one hand, and steel and formwork workers on the other. No notable difference was shown in the WMC dimension between supervisors and laborers. It can be concluded that since high-risk operations in steel work, such as scaffolding, typically involve overt safety hazards associated working at heights and outdoor operations, there is an expectation of a relatively high safety perception. There is no significant gap in SC perception between laborers and site managers for the dimensions STP, SMM, and WMC respectively.

Table 7. Post-Tukey comparison of safety climate (SC) perceptions for supervisor and laborer levels.

Positions of Management (I)	Positions of Laborers (J)	Overall SCP	SAT	STP	RDM	SMM	WMC
		AD (I-J)	AD (I-J)	AD (I-J)	AD (I-J)	AD (I-J)	AD (I-J)
		(*p*)	(*p*)	(*p*)	(*p*)	(*p*)	(*p*)
Supervisor	Steel worker	0.49176 * (0.000)	0.60430 * (0.000)	0.26892 (0.224)	1.02060 * (0.000)	0.42099 * (0.001)	0.00491 (1.000)
	Formwork worker	0.45757 * (0.000)	0.43949 * (0.001)	0.20447 (0.642)	0.99884 * (0.000)	0.47443 * (0.000)	0.05587 (1.000)
	Scaffolding worker	0.49482 * (0.000)	0.54881 * (0.046)	0.32028 (0.826)	1.11659 * (0.000)	0.21521 (0.982)	0.19548 (0.994)

Note: * indicates the average difference is significant at the $p < 0.05$ level.

4. Discussion

This study considers the multilevel perceptions of SC between management and laborer levels on construction sites through five SC perception dimensions. The greatest gap in perception between management and labor levels occurs in RDM, conversely the smallest difference in perception is in WMC. The results show no significant correlation between RDM and WMC behaviors. In addition to position levels, factors related to a worker's background, including education, employment stability (measured as firm employed), previous site accidents experienced, and participation in safety training also significantly influence SC performance perceptions. The results also showed that individual awareness of safe work practices is mostly driven by self-cognition, rather than peer interaction. Inattentiveness to worksite safety is the major difference found between management and laborer levels' SC perceptions. In Taiwan, most construction enterprises have no full-time laborers; instead, they recruit laborers on a temporary basis when they have active construction projects. Laborers might be employed by several construction enterprises in the same period when the construction market has a high labor demand. Given temporary employment arrangements, frequent changes in team composition, tight schedule plans, and concurrent works at multiple sites during the same period, Taiwanese laborers predominately focus attention on productivity and overlook the importance of worksite safety. Constructive safety attitudes of workers are positively linked with STP, RDM, SMM, and WMC. For management and laborer levels, positive attitudes towards overall worksite safety improvement ought to be realized through targeted safety improvement measures.

The perception of the workplace SC differs greatly between supervisors and laborers. The most significant gap is found in RDM, possibly due to these two groups having different site condition perspectives, where laborers have a bottom up view of the organization and supervisors have more of a top down view of worksite safety. This type of phenomenon is characteristic of the multilevel construct. Another possible reason for the significant gap in RDM between these two groups might be Taiwan's universal access to education. This high accessibility to tertiary education and social pressure to seek professional jobs potentially limits the younger generations' willingness to take up laborer-level roles, resulting in the progression towards an aging construction laborer workforce. From the questionnaire responses, it shows that laborers are overconfident about their ability to be safe on construction worksites. They display awareness of the environment factors or colleagues' unsafe behaviors but fail to display awareness of their own situations. It might be due to self-confidence and significant experience that laborers tend to believe they can fully implement safety procedures, or their work can be completed in a perfectly safe way, and as a result they might fail to recognize that they are taking risks at worksites.

The RDM dimension correlates strongly with SAT and STP as well as SMM, indicating a need to focus on targeted strategies to enable workers to understand the safety risks of their roles and take the necessary actions to reduce those risks to an acceptable level. Strategies need to include targeted safety training programs, application of humanistic staff management models, establishing open communication between management personnel and laborers, and implementation of industry best practices for job sites.

In the multilevel framework, safety cognition differences between laborers and managers are apparent in the dimensions of SAT, STP, and RDM. These factors are highly related to a worker's personal cognition and can be influenced through strategic engagement. Laborers exhibit lower accident risk cognition than managers. Therefore, regular engagement through activities such as targeted safety training programs are required for workers to enhance worksite safety cognition and attitudes. In addition to highlighting potential jobsite hazards through training programs, contractors must regularly coach their management personnel to further improve site management and safety inspections practices. Regular safety inspection tours should be used to go beyond solely identifying potential hazards and unsafe practices, and endeavor to include factors related to organizational SC dimensions. When interventions such as training and emphasizing safety requirements are undertaken in a positive general organizational climate, they are generally more effective [47]. Considering the unique characteristics of the construction industry, contractors need to establish organizational practices that promote a positive organizational SC. Laborers should be encouraged to self-manage during the construction process and build their capacity to recognize their own safety behaviors and engage with coworkers when unsafe behaviors are observed. Job supervision should involve frequent communications between management and laborers regarding positive safety practices and behaviors. Given the large proportion of laborers employed on a temporary basis, such strategies need to be cognizant of the transient and temporary nature of workers in the industry.

Among Taiwan's construction industry workers, safety managers show a high safety perception level, whereas owner audit and control managers show the lowest safety perception level. In fact, design, audit managers and public works managers' safety perception levels are unexpectedly low considering the nature of their roles. Public works managers are expected to consistently emphasize construction safety in all projects through a high-level of safety-related knowledge; however, results show this is not the current situation in Taiwan's construction industry. Therefore, an industry wide view is required to fully realize significant improvements in worksite safety.

5. Conclusions

Improving the safety performance amongst workers on Taiwanese construction sites requires developing targeted strategies that are based on a deep understanding of the factors which influence SC. In this study, evidence is provided that confirms that the factors which influence SC perceptions in Taiwan are different between laborers and management. The study also provides a characterization of the dimensions where perceptions differ and the factors which influence the differences in perceptions.

Results show that for laborers a range of background factors such as employment type, training and past experiences greatly influence SC perceptions. In the case of motivation to improve safety performance, it is important to understand and leverage off key factors that drive safety behavior.

This study also shows that laborers previously involved in worksite accidents or who work for larger companies tend to emphasize safety issues more than others. In these scenarios, laborers appear to be presented with greater motivation for engaging in safe work behaviors. Such motivation for engaging in safe work behaviors is not apparent in laborers in smaller companies or temporary employment. The findings regarding the different factors that influence SC perceptions provide valuable information to develop government, industry and organizational initiatives to target safety outcomes for construction industry labors. The results show that initiatives to improve safety behavior on Taiwanese construction sites need to focus on strategies where long-term relationships are formed between construction businesses and laborer teams. Such relationships must focus on establishing basic safety expectations amongst laborers and build familiarity with organizational practices and culture as well as support consistent safety training. While this study builds on the extant literature of multilevel SC perception, it is limited solely to observations of the Taiwanese construction industry perspective, which is influenced by the unique traits that characterize the culture and practices of the industry. As such, without further research, there is potential limitations to a broad generalization of the study's outcomes and recommendations presented in a global context.

In the construction industry, enterprises leveraging off the multilevel understanding of key SC dimensions can contribute significantly to the development of positive attitudes towards safety and safe work habits on construction sites. The effectiveness of a site's SC in promoting positive safety behaviors can be greatly enhanced through strategic organizational measures. Potential countermeasures for improving SC on Taiwanese construction sites include improved clarification of safety responsibilities in staff hierarchies, maintaining minimum requirements for worker competencies and qualifications, in addition to regular safety training and engagement on site safety issues. For staff hierarchies, the results show that management has a relatively higher perception of construction SC issues. This higher level of perception can be used for improving laborers' safety attitudes on construction sites by cultivating a positive SC using targeted strategies that account for factors that have both positive and negative influences on safety perceptions. Such management-level strategies need to consider the need for comprehensive safety policies as the basis for strategic interventions such as training programs and targeted safety awareness programs to drive improvements in laborers' attitudes towards worksite safety. From an organizational perspective, building SC requires active communication between management and laborer levels to enhance the two-way exchange of information regarding safety risks in a constructive way, which fosters free and open sharing of potential solutions. In addition to building communication channels, management need to ensure that all laborers, regardless of background or employment type, are continuously encouraged, empowered and rewarded for taking the initiative to protect themselves as well as fellow workers and are supported by a positive organizational culture. These recommendations are proposed based on the observations made in this study. To better understand the effectiveness of such initiatives to improving SC, further research to confirm the effects of safety interventions on multilevel SC dimension measures and safety performance outcomes is required.

The results from this study also reconfirms the importance of managers frequently reiterating and demonstrating their commitment to safety and promoting good SC through practical actions. Since the establishment of SC heavily relies on the safety attitudes and habits of all workers on the site, laborers should be strongly encouraged to take ownership to promote individual and group safety measures and enhance safety vigilance on construction sites. The implications of the large discrepancy between the expected and actual level of safety perception of senior positions such as public work managers are significant, given the ability to influence the direction of safety practices in the construction industry. Further research is required to better understand the factors that result in such influential positions in Taiwan having such low perceptions of safety in the construction industry.

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References

1. Waehrer, G.M.; Dong, X.S.; Miller, T.; Haile, E.; Men, Y. Costs of Occupational Injuries in Construction in the United States. *Accid. Anal. Prev.* **2007**, *39*, 1258–1266. [CrossRef] [PubMed]
2. Sunindijo, R.Y.; Zou, P.X.W. Political skill for developing construction safety climate. *J. Constr. Eng. Manag.* **2011**, *138*, 605–612. [CrossRef]
3. Yilmaz, F.; Celebi, U.B. The importance of safety in construction sector: Costs of occupational accidents in construction sites. *Bus. Econ. Res.* **2015**, *6*, 25.
4. Li, Y.; Ning, Y.; Chen, W.T. Critical Success Factors for Safety Management of High-Rise Building Construction Projects in China. *Adv. Civ. Eng.* **2018**, *2018*, 1516354. [CrossRef]
5. Choudhry, R.M.; Fang, D.; Lingard, H. Measuring Safety Climate of a Construction Company. *J. Constr. Eng. Manag.* **2009**, *135*, 890–899. [CrossRef]
6. Lingard, H.; Cooke, T.; Blismas, N. Do Perceptions of Supervisors' Safety Responses Mediate the Relationship between Perceptions of the Organizational Safety Climate and Incident Rates in the Construction Supply Chain? *J. Constr. Eng. Manag.* **2012**, *138*, 234–241. [CrossRef]
7. Pinto, A. QRAM a Qualitative Occupational Safety Risk Assessment Model for the construction industry that incorporate uncertainties by the use of fuzzy sets. *Saf. Sci.* **2014**, *63*, 57–76. [CrossRef]
8. Zhang, R.P.; Lingard, H.; Nevin, S. Development and validation of a multilevel safety climate measurement tool in the construction industry. *Constr. Manag. Econ.* **2015**, *33*, 818–839. [CrossRef]
9. Lingard, H.; Wakefield, R.; Blismas, N. If you cannot measure it, you cannot improve it: Measuring health and safety performance in the construction industry. In Proceedings of the 19th Triennial CIB World Building Congress, Brisbane, Australia, 5–9 May 2013.
10. Cheng, C.W.; Lin, C.C.; Leu, S.S. Use of association rules to explore cause—Effect relationships in occupational accidents. *Saf. Sci.* **2010**, *48*, 436–444. [CrossRef]
11. Zohar, D. Thirty years of safety climate research: Reflections and future directions. *Accid. Anal. Prev.* **2010**, *42*, 1517–1522. [CrossRef]
12. Noort, M.C.; Reader, T.W.; Shorrock, S.; Kirwan, B. The relationship between national culture and safety culture: Implications for international safety culture assessments. *J. Occup. Organ. Psychol.* **2016**, *89*, 515–538. [CrossRef] [PubMed]
13. Hinze, J.; Thurman, S.; Wehle, A. Leading indicators of construction safety performance. *Saf. Sci.* **2013**, *51*, 23–28. [CrossRef]
14. Mohamed, S. Scorecard Approach to Benchmarking Organizational Safety Culture in Construction. *J. Constr. Eng. Manag.* **2003**, *129*, 80–88. [CrossRef]
15. Hecker, S.; Goldenhar, L. Understanding safety culture and safety climate in construction: Existing evidence and a path forward. In *Literature Review Summary for Safety Culture/Climate Workshop*; CPWR—The Center for Construction Research and Training: Silver Spring, MD, USA, 2013.
16. Choudhry, R.M.; Fang, D.; Mohamed, S. The nature of safety culture: A survey of the state-of-the-art. *Saf. Sci.* **2007**, *45*, 993–1012. [CrossRef]
17. O'Connor, P.; Buttrey, S.E.; O'Dea, A.; Kennedy, Q. Identifying and addressing the limitations of safety climate surveys. *J. Saf. Res.* **2011**, *42*, 259–265. [CrossRef] [PubMed]
18. Mearns, K.J.; Flin, R. Assessing the state of organizational safety—Culture or climate? *Curr. Psychol.* **1999**, *18*, 5–17. [CrossRef]

19. Clarke, S.; Ward, K. The Role of Leader Influence Tactics and Safety Climate in Engaging Employees' Safety Participation. *Risk Anal.* **2006**, *26*, 1175–1185. [CrossRef] [PubMed]
20. Tomás, J.M.; Cheyne, A.; Oliver, A. The relationship between safety attitudes and occupational accidents: The role of safety climate. *Eur. Psychol.* **2011**, *16*, 209–219. [CrossRef]
21. Teo, E.A.L.; Feng, Y. The role of safety climate in predicting safety culture on construction sites. *Archit. Sci. Rev.* **2009**, *52*, 5–16. [CrossRef]
22. Dedobbeleer, N.; Béland, F. A safety climate measure for construction sites. *J. Saf. Res.* **1991**, *22*, 97–103. [CrossRef]
23. Shen, Y.; Koh, T.Y.; Rowlinson, S.; Bridge, A.J. Empirical Investigation of Factors Contributing to the Psychological Safety Climate on Construction Sites. *J. Constr. Eng. Manag.* **2015**, *141*, 4015038. [CrossRef]
24. Shen, Y.; Tuuli, M.M.; Xia, B.; Koh, T.Y.; Rowlinson, S. Toward a model for forming psychological safety climate in construction project management. *Int. J. Proj. Manag.* **2015**, *33*, 223–235. [CrossRef]
25. Zhou, Q.; Fang, D.; Mohamed, S. Safety Climate Improvement: Case Study in a Chinese Construction Company. *J. Constr. Eng. Manag.* **2011**, *137*, 86–95. [CrossRef]
26. Lingard, H.C.; Cooke, T.; Blismas, N. Properties of group safety climate in construction: The development and evaluation of a typology. *Constr. Manag. Econ.* **2010**, *28*, 1099–1112. [CrossRef]
27. Zhang, P.R.; Pirzadeh, P.; Lingard, H.; Nevin, S. Safety climate as a relative concept: Exploring variability and change in a dynamic construction project environment. *Eng. Constr. Archit. Manag.* **2018**, *25*, 298–316. [CrossRef]
28. Zahoor, H.; Chan, A.P.; Utama, W.P.; Gao, R. A Research Framework for Investigating the Relationship between Safety Climate and Safety Performance in the Construction of Multi-storey Buildings in Pakistan. *Procedia Eng.* **2015**, *118*, 581–589. [CrossRef]
29. Gao, R.A.N.; Chan, A.P.C.; Utama, W.P.; Zahoor, H. Review and adopt a tool for measuring safety climate in international construction projects. In Proceedings of the 8th International Structural Engineering and Construction Conference (ISEC-08), Sydney, Australia, 23–28 October 2015.
30. Ghosh, S.; Young-Corbett, D.; Fiori, C.M. Emergent Themes of Instruments Used to Measure Safety Climate in Construction. In Proceedings of the Construction Research Congress, Banff, AB, Canada, 8–10 May 2010; pp. 1010–1019.
31. Glendon, A.; Litherland, D. Safety climate factors, group differences and safety behaviour in road construction. *Saf. Sci.* **2001**, *39*, 157–188. [CrossRef]
32. Fang, D.; Chen, Y.; Wong, L. Safety Climate in Construction Industry: A Case Study in Hong Kong. *J. Constr. Eng. Manag.* **2006**, *132*, 573–584. [CrossRef]
33. Kines, P.; Lappalainen, J.; Mikkelsen, K.L.; Olsen, E.; Pousette, A.; Tharaldsen, J.; Tomasson, K.; Törner, M. Nordic Safety Climate Questionnaire (NOSACQ-50): A new tool for diagnosing occupational safety climate. *Int. J. Ind. Ergon.* **2011**, *41*, 634–646. [CrossRef]
34. Cigularov, K.P.; Adams, S.; Gittleman, J.L.; Haile, E.; Chen, P.Y. Measurement equivalence and mean comparisons of a safety climate measure across construction trades. *Accid. Anal. Prev.* **2013**, *51*, 68–77. [CrossRef]
35. Wu, C.; Song, X.; Wang, T.; Fang, D. Core Dimensions of the Construction Safety Climate for a Standardized Safety-Climate Measurement. *J. Constr. Eng. Manag.* **2015**, *141*, 4015018. [CrossRef]
36. Newaz, M.T.; Davis, P.R.; Jefferies, M. Developing a safety climate factor model in construction research and practice: A systematic review identifying future directions for research. *Eng. Constr. Archit. Manag.* **2018**, *25*, 738–757. [CrossRef]
37. Zohar, D. Safety climate in industrial organizations: Theoretical and applied implications. *J. Appl. Psychol.* **1980**, *65*, 96–102. [CrossRef] [PubMed]
38. Flin, R.; Mearns, K.; Oconnor, P.; Bryden, R. Measuring safety climate: Identifying the common features. *Saf. Sci.* **2000**, *34*, 177–192. [CrossRef]
39. Gao, R.; Chan, A.P.C.; Utama, W.P.; Zahoor, H. Workers' Perceptions of Safety Climate in International Construction Projects: Effects of Nationality, Religious Belief, and Employment Mode. *J. Constr. Eng. Manag.* **2017**, *143*, 4016117. [CrossRef]
40. Huang, Y.H.; Verma, S.K.; Chang, W.R.; Courtney, T.K.; Lombardi, D.A.; Brennan, M.J.; Perry, M.J. Supervisor vs. employee safety perceptions and association with future injury in US limited-service restaurant workers. *Accid. Anal. Prev.* **2012**, *47*, 45–51. [CrossRef] [PubMed]

41. Gillen, M.; Baltz, D.; Gassel, M.; Kirsch, L.; Vaccaro, D. Perceived safety climate, job demands, and coworker support among union and nonunion injured construction workers. *J. Saf. Res.* **2002**, *33*, 33–51. [CrossRef]
42. Okoye, P.U.; Aderibigbe, Y.W. Comparative assessment of safety climate of casual and permanent construction workers in South-East Nigeria. *Int. J. Health Psychol.* **2014**, *2*, 54–66.
43. Marin, L.S.; Cifuentes, M.; Roelofs, C. Results of a community-based survey of construction safety climate for Hispanic workers. *Int. J. Occup. Environ. Heal.* **2015**, *21*, 223–231. [CrossRef]
44. Cheng, C.W.; Lin, C.C. Identifying limitations and breakthroughs regarding safety management in construction industry according to the causes of major occupational accidents. *J. Labor Occup. Saf. Health* **2017**, *25*, 24–37.
45. Hinton, P.R.; McMurray, I.; Brownlow, C. *SPSS Explained*; Roultledge: London, UK, 2004.
46. Nunnally, J.C. *Psychometric Theory*; McGraw Hill: New York, NY, USA, 1978.
47. Neal, A.; Griffin, M.; Hart, P. The impact of organizational climate on safety climate and individual behavior. *Saf. Sci.* **2000**, *34*, 99–109. [CrossRef]