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Critical Factors Affecting the Safety Communication of Ethnic Minority Construction Workers

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Abstract: Ethnic minority workers (EMWs) or migrant workers continue to be confronted with communication problems, which can have serious effects on safety outcomes. This study aims to help improve construction industry EMW safety communication by uncovering and analyzing the criticality, underlying constructs, and explanatory power of the influencing factors involved. A mixed research design is employed by combining a literature review, semi-structured interviews, and questionnaire survey. Following the identification of an initial set of safety communication factors (SCFs) and a questionnaire designed and administered to EMWs in the Hong Kong and Australian construction industry, a total of 134 valid responses are analyzed through mean scoring, factor analysis and importance-explanation analysis. Eighteen critical EMW SCFs are identified and categorized into three groups of worker-related SCFs, manager-related SCFs and organization-related SCFs. A set of 36 SCFs identified can be not only used to examine the relative importance of EMW SCFs, but can also be adopted to capture the critical SCFs for both local and EM construction workers in other countries. Narrowing a wide range of SCFs for EMWs provides stakeholders with the insights needed to the key contributory factors of safety communication, which, in turn, has a positive impact on safety performance. Despite this study being conducted in Hong Kong and Australia, its findings can

also be used as a reference for other countries where EMWs are employed (e.g., the U.S., U.K., Canada, Middle East, Malaysia, Singapore, and South Africa).

Keywords: Safety communication, Safety and health, Ethnic minority, Migrant workers, Construction workers

Practical Applications

Safety communication is a major safety challenge for EMWs and effective safety communication leads to improved safety performance and decreased injuries and fatalities. This research provides extra information on the key issues of safety communication that associated stakeholders need to address for EMWs to help them understand and mitigate the main safety communication barriers. This study suggests that apart from some measures (e.g., language courses, understandable safety training and safety materials, and bilingual translators) that have been taken for improving EMW safety communication in many countries, governments and employers are recommended to adopt multi-faceted strategies manipulating worker-, manager- and organization-related SCFs that would be more effective than a single measure. The critical roles of managers and organization in promoting EMW safety communication are also emphasized in this study. Future efforts to improve or develop programs or interventions for EMW safety communication can benefit from this study by referring to the critical SCFs to include each aspect of safety communication. Furthermore, the identified critical SCFs will also help industry practitioners diagnose deficiencies in EMW safety management practices.

1. Introduction

The construction industry in many countries (e.g., the U.S., the U.K., Canada, Australia, United Arab Emirates, Israel, Qatar, Malaysia, Singapore, South Africa, Korea, and Thailand) is highly dependent on migrant workers or ethnic minority workers (EMWs), defined as groups with different national or cultural traditions from the main population in this study. The proportion of EMWs in the total construction workforce is approximately 30.4% in the U.S. (U.S. Bureau of Labor Statistics 2020), 10% in the U.K. (Office for National Statistics 2018), 69% in Malaysia (Abdul-Rahman et al., 2012), and 16% in Australia (DIAC 2009). In Hong Kong, the number of EMWs generally increased significantly from 342,198 in 2006 to 584,383 in 2016 (Census and Statistics Department 2016, p. 7), with 11.3% of all male EMWs employed in the construction sector (Census and Statistics Department 2016, p. 90). The construction industry is identified as one of the most accident-prone sectors worldwide, while EMWs are more vulnerable groups, as revealed by various statistics indicating the high workplace accident rate regarding EMWs (Evia and Patriarca 2012; Hallowell and Yugar-Arias 2016; Lyu et al. 2018). For instance, in the UK construction industry, although EMWs represented only 8% of the workforce in 2007/2008, they accounted for 17% of construction deaths (Centre for Corporate Accountability 2009). In the U.S., Hispanic construction workers made up 25.5% and 27.3% of the total construction workforce in 2012 and 2013, but accounted for 27.4% and 29.1% of the total fatalities (Hallowell and Yugar-Arias 2016). In the Hong Kong construction industry, EMWs made up 1.5% of the workforce and contributed to at least 6.4% of the death toll from 2000 to 2016 (Lyu et al. 2018).

Given concerns over alarming rates of injuries and fatalities of EMWs, there has been a growing body of research especially aimed at improving EMW safety management (see Section 2.3 for details). Of these studies, only a few specially target EMW safety communication problems in the construction industry. Safety communication is greatly important and has the potential to positively affect safety performance within an organization (Hardison et al. 2014). Due to significant differences in the safety legislation, regulations, standards, and work methods from country to country and cultural and language disparities, communication barriers are one of the main challenges faced by EMWs (Chan et al. 2016; Lyu et al. 2018; Oswald et al., 2019) and thus effective communication is difficult to achieve (Cheung et al. 2013). Miscommunication among or with EMWs leads to many negative consequences on construction sites, such as difficulties in identifying risks, reporting risky situations, rejecting unsafe tasks, expressing worries, and even understanding safety instructions (Guldenmund et al. 2013; Trajkovski and Loosemore 2006). Thus, there is a vital need for research into the contributory factors of safety communications of EMWs working in the construction industry. Existing studies of EMWs highlighted safety communication being a problem. Some of them touched on safety communication factors but since many of these studies have a wider focus (not focusing on revealing all the possible factors of safety communication) and therefore did not provide in depth analysis on all possible factors of safety communication. existing studies are qualitative (e.g., Tutt et al. (2013)) and the relative importance of SCFs has not been quantified based on the perceptions of EMWs. This study therefore aims to address this important research gap by analyzing the critical SCFs involved through a survey of EMWs working in the Hong Kong and Australian constriction industry. The specific research objectives (ROs) are: *RO1.* To identify a comprehensive list of EMW communication factors by literature review and interviews; *RO2.* To identify the critical EMW SCFs from the list obtained in *RO1* based on EMW perceptions; *RO3.* To explore the groups underlying the critical EMW SCFs identified in *RO2*; *RO4.* To evaluate the relative importance and explanatory power of the critical EMW SCFs based on the results of *RO2 and RO3*.

This study's contribution is to extend the existing literature regarding safety communications in the context of occupational safety, as most previous studies have focused on the role of effective safety communications in decreasing occupational near-misses, injuries or fatalities (Bentley and Haslam 2001; Smith et al. 1978), improving safety climate (Kines et al. 2010; Liao et al. 2014) as well as enhancing safety behaviors (Cigularov et al. 2010; Liao et al. 2014; Mattila et al. 1994). A relatively a small body of literature, however, has examined the factors that could affect safety communication and of these limited studies only a few SCFs of EMWs have been identified. The present study takes a step back and explores the factors that EMWs perceive to be important for their effective safety communication on construction sites. This study produces a comprehensive list of construction industry EMW SCFs, which provides valuable insights for future research by offering a whole picture of the antecedents of safety communication for construction workers. In addition, narrowing a wide range of SCFs for EMWs provides stakeholders with the insights needed to the key contributory factors of safety communication. The analysis of the criticality of EMW SCFs can be used to identify and prioritize the communication needs of EMWs in practice and for further research investigation.

2. Literature Review

2.1. Communication theory and definition of safety communication

Communication is the transmission of information and meaning from one individual or group to another (Guffey and Loewy 2010) and *communication theory* has existed for more than 2,500 years (Philipsen and Albrecht 1997). The key elements of communication process in communication models comprise the sender, receiver, noise and distortion, message, communication channels, communication media, feedback, and cultural context (Dainty et al. 2007). Various definitions of communication exist due to differences in the perspectives. As the present study is conducted in the context of construction, the definition applied is based on Dainty et al.'s (2007, p. 5) "… a professional practice where appropriate rules and tools can be applied in order to enhance the utility of the information communicated, as much as it can a social process of interaction between people." Safety communication in this study is thus defined as "a professional practice where appropriate rules and tools can be applied in order to enhance the utility of the safety and health related information communicated onsite".

Safety communication is generally a two-way process by which communicators send and receive safety-related messages through a communication medium and channel and provide feedback that might be distorted by noise and context on construction sites (Dainty et al. 2007; DeVito 2011). As indicated by the UK Health and Safety Executive (HSE 2005; Al-Bayati et al., 2016), effective safety communication consists of three directions namely, management to frontline workers (top-down communication), frontline workers to management (bottom-up communication) and between co-workers (horizontal communication). Based on such previous studies as Butt et al. (2016) and Weaver (2007), effective safety communication is defined as relevant and correct safety related information in three directions of communication being successfully encoded, delivered through appropriate channels, received, and properly decoded and understood by receivers. The perceived effectiveness of communication can be measured by five items (Gudykunst and Nishida 2001), e.g., "My communication with this person was not successful."

2.2. Effects of safety communication

Effective communication is a significant component of safety management practices to improve safety in the workplace (Vinodkumar and Bhasi 2010). Researchers from a wide range of fields identify the importance of safety communication in safety-related issues. For instance, Hofmann and Morgeson (1999) demonstrate that a manufacturing facility's employees with good-quality communication with their management tended to feel free to raise safety concerns, and safety communication significantly affected safety commitment, which further predicts the occurrence of accidents; Michael et al. (2006) investigation of the effects of safety communication between supervisors and subordinates in wood manufacturing companies shows that safety communication has a direct effect on recordable injuries.

In the construction sector, communication between construction has attracted increasing interest from researchers and practitioners in the construction domain (Choon Hua et al. 2005). Communication has been found to affect individual psychological state, organizational climate, safety behaviors, safety performance, work-related pain of construction workers (Cigularov et al. 2010). The frequency and method of safety communication are significant distinguishing indicators of high and low safety performing teams (Alsamadani et al. 2013b). Safety communication influences safety climate (Cigularov et al. 2010) and the relationship between communication and safety climate is mediated by person-organization fit (Liao et al. 2013). The most effective communication style (i.e., coaching) helps to reduce cognitive failure of construction workers and therefore decrease unsafe construction behaviors (Liao et al. 2014). These studies indicate the significance of safety communication in enhancing safety outcomes.

2.3. EMW safety management and safety communication

Due to concerns over the high rate of EMW injuries and fatalities, an increasing number of studies have been conducted that are especially aimed at improving EMW safety management. These can be divided into six categories as follows.

(1) Exploring the safety challenges faced by EMWs (e.g., Shepherd et al. 2021; Chan et al. 2017b; Oswald et al. 2018; Hallowell and Yugar-Arias 2016). For instance, five challenges influencing the safety of EMWs have been identified by interviews and focus groups in Italy, Spain and the UK, such as the increased use of subcontractors and dilution of safety standards down the supply chain (Shepherd et al. 2021).

(2) Investigating safety climate and its relationship with safety performance (e.g., Chan et al. 2017a, 2017c; Lyu et al. 2018). This group identified and evaluated the underlying constructs of safety climate perceived by EMWs (Chan et al. 2017a, 2017c), and further revealed the significant positive relationships between safety climate and safety behaviors (Lyu et al. 2018).

(3) Analyzing the accidents, injuries, illness, or fatalities of EMWs (e.g., Goodrum and Dai 2005; Al-Bayati et al. 2016; Martínez-Rojas et al. 2021). Disparities in injuries, illnesses, and fatalities between non-Hispanic and Hispanic construction have been found in the U.S.

(Goodrum and Dai 2005). Two differences in culture (i.e., high power distance and collectivism) have been found to be related to the EMW safety (Al-Bayati et al. 2016).

(4) Comparing the difference in safety levels between EMWs and native construction workers (e.g., Cigularov et al. 2013; Korkmaz and Park 2018; Goodrum and Dai 2005).

(5) Designing and evaluating pictorial methods, safety training and interventions for EMWs (e.g., Vignoli et al. 2021; Nielsen et al. 2021; Hussain et al. 2018). Safety training and interventions targeting EMWs are designed, and their effectiveness are evaluated. The use of safety training and interventions is found to result in a significant improvement of training-transfer (Hussain et al. 2018).

(6) EMW safety communication (e.g., Loosemore and Lee 2002; Bust et al. 2008b; Trajkovski and Loosemore 2006). Due to significant differences in safety legislation, regulations, standards, and work methods between country and country and cultural and language disparities, communication is one of the main challenges faced by EMWs (Chan et al. 2017b; Oswald et al. 2019). Loosemore and Muslmani (1999), Loosemore and Lee (2002), and Phua et al. (2011) found language differences resulting from the mix of various ethnicities are the major cause of EMW communication problems. Bust et al. (2008b) revealed that some initiatives (e.g., translated safety materials, employment of translators, and a visual approach) are being adopted to communicate EMW safety messages, but indicated that little has been done to assess their effectiveness. Miller et al. (2000) point out, EMWs have difficulties in understanding idiomatic languages expressed by native workers, which results in communication barriers between EMWs and their local counterparts. Trajkovski and Loosemore (2006) regard mandatory safety training and print materials in the native languages of EMWs as necessary. Hare et al. (2012) found that EMWs' understanding of safety images is influenced by nationality, work experience, and cultural differences. Tutt et al.'s (2013) ethnographic study revealed the communication patterns used by EMWs to learn and share

safety knowledge. Meanwhile, instead of analyzing the communication of individual workers, Lyu et al. (2020) focused on EMW crews by modelling the predominant safety communication patterns in Hong Kong and found that some characteristics of safety communication networks (e.g., network density and level of reciprocity) are related to safety performance, and some personal traits (e.g., age, language ability) of EMWs affect their positions in networks.

2.4. Communication factors in the construction and other sectors

Some studies have explored significant factors that affect the effectiveness of communication by the construction project team and stakeholders. Preece and Stocking (1999) analyze the process of communicating construction safety information and identify eight major barriers to effective and efficient safety communication; Dickens (2002) identify and evaluate the factors that affect the receivers' understanding of messages in construction projects; Wong et al. (2004) uncover 56 factors influencing the safety communication between main contractors and subcontractors in Hong Kong identifies seven adverse and six positive factors; while Choon Hua et al. (2005) focus on the communication factors between building clients and maintenance contractors. Ejohwomu et al. (2017) identify 15 factors influencing communication in the Nigerian construction industry grouped into two categories of (1) managerial and technical barriers and (2) credibility and background. Cheung et al. (2013) find the roles of trust affect communication. Cross-cultural communication occurs frequently at construction sites in international construction projects, which are more complicated due to the differences in the languages and cultures involved, with Tone et al. (2009), for instance, revealing that cross-cultural communication tends to have a more negative than positive effect on the management of construction projects, identifying 26 barriers to effective communication.

Studies of communication factors in the healthcare, international business and education domains have been a step ahead in terms of effective communication and cross-cultural communication. Many researchers in these sectors make important contributions to solve communication problems (Degni et al., 2012; Tay et al., 2011) and demonstrate that effective communication has such positive outcomes as decreasing anxiety and pain and increasing patient satisfaction and compliance (Norouzinia et al., 2016). These studies are summarized in Table 1 and organized into 36 communication factors.

[Insert Table 1 here]

2.5. Gap in knowledge

The aforementioned studies of EMW safety communication have identified a few possible contributory factors, including language ability, translation of safety training and print safety materials, personal traits, work experience, cultural difference, use of visual methods, and employment of translators. None of these are comprehensively however, raising the question of, apart from these, are there any other potential SCF of EMWs yet to be identified? Moreover, of all possible EMW SCFs, which do EMWs regard as the most critical? In view of communication factors identified in other sectors, it could be assumed that, except for these factors, there would be more contributory factors to effective EMW safety communication. However, there are no explicit studies of safety communication of EMWs that have focused on identifying a comprehensive set of EMW SCFs. Furthermore, the relative importance of SCFs has not yet analyzed. This is the research gap that this study aims to fill.

3. Research Methodology

Fig. 1 depicts the overall flow of the research methods adopted in this study. A multilingual questionnaire survey designed through literature review and interviews is conducted to gather EMWs' views on the relative importance of SCFs and analyzed by mean scoring, factor analysis, and importance-explanation.

[Insert Fig. 1 here]

3.1. Questionnaire Design

3.1.1. Questionnaire development

Due to the lack of a pre-established list of SCFs, a new questionnaire was designed based on the following three steps:

Literature review. The study started with a review of communication theory and research into communication in the settings of construction management, business, health care, and education. SCFs with similar meanings were renamed and grouped together (see Section 2).

Semi-structured interviews. A total of 18 professionals (Interviewees A to R) involved in managing EMWs were interviewed to explore the factors that have influenced EMW safety communications (see Table 2). Three interview questions were asked: (1) what the key success factors of effective EMW safety communications are; (2) what the major safety communication problems of EMWs are; and (3) what measures should be taken to improve EMW safety communications. 15 EMW SCFs were identified from interviews (see Table 3), of which 14 were consistent with the factors derived from the literature review. One SCF (in bold) (not identified in the literature was added, resulting in 37 SCFs in total. Employment of safety staff from workers' origin country is one of the normal practices adopted by management onsite in the Hong Kong. Interviews argues that a ganger and safety supervisor who could speak the EMW's native language and local language were the communication bridges between local management and EMWs.

[Insert Table 2 here]

[Insert Table 3 here]

Expert evaluation. Some modifications were made according to the comments and recommendations from one industrial and two academic experts, such as combining the two similar SCFs of "Not pretending to understand" and "Providing feedback from workers to management", which reduced the number of SCFs back to 36 (see Table 5).

The final version of the questionnaire has two sections. Section A comprises 17 questions regarding the respondent's background (e.g., country of origin; work trade; age; work experience in construction; education level; direct employer; length of service with the current project; and languages fluent in and languages used for written material, safety training and meetings). Section B contains 36 questions regarding the factors that may affect the effectiveness of safety communication, with their importance for improving safety communication rated on a five-point Likert scale, from 1 (not important) to 5 (very important).

3.1.2. Questionnaire translation

The questionnaire in English was firstly designed and translated into the native languages of frontline EMWs for their convenience. To ensure the equivalence of meanings, the questionnaire was translated by professional translation companies into different languages, such as Nepali (for Nepalese workers), Urdu (for Pakistani workers), Chinese (for Chinese workers) and Korean (for South Korean workers), and then back-translated into English by native Nepalese-, Pakistani-, Korean- and Chinese-speakers with experience in construction management. The research team carefully examined the back-translations to identify discrepancies which were corrected until it became clearly unambiguous.

3.2. Research Sampling

The population of the present study is focused on the EMWs working in the Hong Kong and Australian construction industry as a large proportion of EMWs are employed in these two jurisdictions (see Section 1) and its proximity to the researchers. Considering the lack of a comprehensive list of all units in the whole EMWs in the Australian and Hong Kong construction industry, a non-probability, non-random sampling method, i.e., a purposive sampling technique, was used to select the targeted survey respondents. It is normally adopted to select respondents by EMW studies, as the actual number of EMWs in the construction industry is unavailable in many countries (e.g., Rotimi et al. 2021; Jiang et al. 2020, Shepherd et al. 2021). For instance, Rotimi et al. (2021) adopted the purposive sampling method for collecting questionnaire data from EMWs, as they regarded that a broad group of cases can be well presented by the selected participants.

Of the 87 companies contacted, a total of 12 construction companies in Hong Kong and 10 in Australia participated in the survey. Each company was suggested to randomly choose around ten EMWs for avoiding clustering problem in a specific construction company. Most of questionnaires were completed face-to-face on sites, with others collected through online survey. To reduce response bias, managers did not show up and translators were trained and employed to explain the research aim and questions. The number of questionnaires distributed is 200 (100 in Hong Kong and 100 in Australia) and a total of 150 questionnaire were collected (85 in Hong Kong and 65 in Australia). After removing invalid responses, this produces a total of 134 responses with an overall response rate of 67%. This sample size and return rate is regarded as sufficient for the intended subsequent analysis compared with other similar studies in the construction industry. For instance, Wong and Lin (2014) collected 100 valid questionnaires from EMWs in Hong Kong with a 77% response rate and the sample size Rotimi et al. (2021) was 108 EMWs on five major projects in New Zealand with a 54% response rate.

To compensate for the lack of randomization of the non-probability sampling method, a high degree of diversity of respondents was achieved during data collection (see Table 4), e.g., different nationalities, ages, work experience in construction, and length of service with the current company. As such, the collected sample represented a reasonably convincing cross-section sample of the whole population (Gravetter and Forzano 2018).

[Insert Table 4 here]

3.3. Data Analysis Methods

3.3.1. Mean scoring technique

The mean score method has been widely used in construction and project management to establish the relative importance of influencing factors (Zhao et al. 2014). Here, mean scoring is used to determine the SCF rankings, with the standard deviation determining the rank in the event of tied mean score (see Table 5). Following Xu et al. (2010) and Zhao et al. (2014), normalized mean scores calculated by Eq. (1) greater than 0.50 are taken to be the critical SCFs (see Table 5). The independent-samples *t*-test is conducted to investigate the differences in the perceptions of critical SCFs by Hong Kong and Australia EMWs groups.

$$\text{Normalised mean scores} = \frac{\text{mean} - \text{minimum mean}}{\text{maximum mean} - \text{minimum mean}} \tag{1}$$

3.3.2. Factor analysis

Exploratory factor analysis (EFA) with principal component (PCA) as the most widely used extraction method (Thompson 2004) is firstly used to detect the underlying constructs of the critical SCFs using SPSS version 21.0. Kaiser-Mayer-Olkin (KMO) coefficient and Barlett Sphericity Test are applied to examine the suitability of data to conduct factor analysis (Hair et al., 2010). The KMO value higher than 0.5 and the significance level of Bartlett's test of sphericity lower than 0.05 are regarded as suitable to conduct factor analysis (Hair et al., 2010). Kaiser's (1960) criterion, scree test (Cattell, 1966), Horn's (1965) parallel analysis, and the interpretability of the factors (Fabrigar and Wegener 2011) were all taken into consideration to determine the number of constructs to be extracted. As recommended by Tabachnick and Fidell (2001) in terms of the factor rotation method selection, oblique rotation needs to be adopted when the correlations among constructs is greater than 0.32; otherwise, the orthogonal rotation method should be used. Once the factor matrix is generated, factor loadings are checked to identify and delete the items that have not loaded on any factor with significantly high factor and the cut-off value of factor loading is set at 0.60 (Hair et al. 2010).

The questionnaire data are further analyzed by Confirmatory Factor Analysis (CFA) to test the relationship between the observable and latent variables and test if the data fit the measurement model using AMOS 21. Four criteria of indices are used to assess the fitness of the measurement model (see Table 7). For reliability of construct, a Cronbach alpha coefficient > 0.70 is regarded as "sufficient" internal consistency (Nunally and Bernstein, 1994) along with a Composite reliability (CR) of 0.7 (Hair et al., 2010). Validity is also assessed by standardized item loadings of > 0.50 (preferably 0.70), the rule of thumb of average variance extracted (AVE) of at least 0.50 (Hair et al., 2010), with the AVE of a particular construct more than its squared factor correlation with other constructs (Fornell and Larcker, 1981; Xiong et al., 2015).

3.3.3. Importance-explanation analysis

Importance-explanation analysis (IEA) is adapted from importance-performance analysis (see Fig. 2), which has been applied as an effective approach by researchers. For instance, Chou et al. (2012) apply it to evaluate the critical factors for public-private partnership policy. The two dimensions of IEA refer to mean scores and standardized factor loading coefficients of items. While mean scoring is suitable for evaluating the relative importance of items, it is unable to assess the items' covariance, as it assumes that each is independent. Factor loadings derived from structural equation modelling can measure the explanatory power of items, which can remedy this mean scoring defect (Chou and Pramudawardhani 2015). IEA combines mean scoring and factor loading, with mean scoring evaluating relative importance and factor loading evaluating explanatory power. Here, IEA is used to evaluate the importance and explanatory power of the critical SCFs. The results then reveal the most important factors that should be taken into consideration to improve construction industry EMW safety communications.

[Insert Fig. 2 here]

4. Research Results

4.1. Identifying the Critical SCFs

As shown in Table 5, the mean scores of the SCFs range from 3.38 to 4.13. A total of 18 factors has normalized values >0.50, indicating their criticality − the three most important being "Adequacy of language ability of workers" (D5), "Personality characteristics of workers" (D6) and "Adequacy of workers' work experience in construction" (D4). A comparison of critical EMW SCFs between Hong Kong and Australia is evaluated by *t*-test and the result shows that the Hong Kong and Australia EMWs have significantly different views for only one (starred) of the critical SCFs, namely D26 (see Table 5). Safety staff from worker' origin country have been employed in some companies in Hong Kong, which makes EMCWs in Hong Kong feel comfortable to communicate and regards it helpful. Thus, EMCWs in Hong Kong perceive this factor more important.

[Insert Table 5 here]

4.2. Grouping the Critical SCFs

To identify the underlying groups, 18 critical SCFs are analyzed by EFA. The ratio between 134 cases and 18 items is 7.4 (> 5.00), indicating the sample size is sufficient to conduct an EFA (Gorsuch 1983). Furthermore, the KMO value is 0.916, which indicates excellent sampling adequacy for factor analysis (Kaiser 1960). Bartlett's test of sphericity produces an approximate chi-square of 1921.020 (df = 153, p < 0.001), which supports the normal distribution assumption. All these demonstrate the suitability of data on SCFs for conducting an EFA. Based on the results of Scree plot and the interpretability of the factors, the optimal solution comprises three factors, in which the items loading on each factor have a conceptual meaning, and the items loading on different factors measure different constructs. As the maximum correlation coefficient between each construct is higher than 0.32, oblique rotation is conducted. The rotated pattern and structure matrix of the three groups of critical SCFs are presented in Table 6. All factor loading greater than 0.60 and the extracted three constructs explained 71% of total variance of the results. Based on the common characteristics of items loading on each construct, the first construct is labelled "Workers-related SCFs" (WFEM) and comprises six variables, the second construct is labelled "Manager-related SCFs" (MFEM) and consists of seven items, and the third construct is labelled "Organization-related SCFs" (OFEM) and includes five items.

[Insert Table 6 here]

CFA was conducted to confirm the factor structure that obtained by EFA. The results of multiple goodness-of-fit indices are shown in Table 7. All four criteria are met, indicating it fits the research data well. As listed in Table 8, Cronbach's alpha values for WFEM, MFEM and OFEM are 0.932, 0.914 and 0.895, and the CR values for these groups range from 0.898 to 0.934, which are all higher than their respective thresholds 0.70. The standardized factor loadings coefficients of all observed variables ranging from 0.72 to 0.92 exceeds the threshold 0.50. The values of AVE range within 0.602-0.704, which are higher than the suggested threshold 0.50. The values of AVE in bold along diagonal exceed the squared correlation coefficients in its rows and columns. Therefore, the measurement models are reliable and valid. The standardized parameters of the CFA model for SCFs are shown in Fig. 3, in which the factor loading paths from 18 observed variables to three latent variables and measurement error variances are included.

[Insert Table 7 here]

[Insert Table 8 here]

[Insert Fig. 3 here]

4.3. Importance-Explanation Analysis

The mean scores and factor loadings are analyzed to determine the relative importance and explanation power of each factor in the three groups respectively (i.e., WFEM, MFEM and OFEM). Fig. 4 shows diagrams of the importance-explanation analysis for the simultaneous comparison of mean scores and factor loadings in groups WFEM, MFEM and OFEM, respectively. In the first group, WFEM, the factor loadings of D1, D4, D5, D6, D9 and D10 range from 0.779 to 0.924 and mean scores range from 3.96 to 4.13 for factors in WFEM. Item D5, "Adequacy of language ability of workers", is in Quadrant I, indicating that it had the highest importance and explanation power in this group. In the second group, MFEM, the factor loadings of D12, D13, D17, D21, D22, D14 and D24 range from 0.744 to 0.860 and mean scores range from 3.90 to 4.04. Item D24, "High quality of supervisor-subordinate relationship", is in Quadrant I and identifies as the most important and explanatory in the group of MFEM. In the third group, OFEM, the factor loadings of D26, D27, D31, D33 and D34 range from 0.717 to 0.858 and mean scores range from 3.80 to 3.93. Three factors are in Quadrant I and are considered the most important and explanatory in the OFEM group, including D34, "Not much time pressure for completion of the project", D33, "Organizational support and concern", and D27, "Application of pictorial or visual safety materials".

[Insert Fig. 4 here]

5. Discussion

Understanding the critical EMW SCFs is vital for improving their safety communication and performance. The present study reveals 18 critical SCFs that explain 71.23% of the total variance, and categorizes them into worker-, manager- and organization-related groups by factor analysis, which is consistent with human communication theory in that the communication process involves an interaction between communicators and is influenced by the environment (Park and Song 2005). Worker-related SCFs (M = 4.03) are regarded as the most important, followed by manager-related SCFs (M = 3.95) and organization-related SCFs (M = 3.90). Considering that critical SCFs falling in the first, second and fourth quadrant have relatively high importance and explanation power, these factors are further discussed below.

5.1. Group 1: Worker-related SCFs (WFEM)

The WFEM group is closely related to EMWs and has the highest mean value among the three groups, which highlights the importance of EMWs in safety communication. Of the six SCFs in this group, "Adequacy of language ability of workers" (D5) has the most explanatory power and importance. Its mean value is also the highest of all the critical SCFs. This result is consistent with the findings of many studies showing that insufficient language skill is the main reason of poor communication, i.e., Guldenmund et al. (2013); Miller et al. (2000). Some EMWs grasp rudimentary local languages, while the others are unable to communicate in local languages. Such a low level of proficiency and literacy is detrimental to their understanding of safety information, and hinders local management in conveying safety instructions in a timely manner (Guldenmund et al. 2013; Huczynski and Buchanan 2001). Interviewees C and E stated that management has difficulty giving instant and on-the-spot warnings to EMWs due to language barriers.

Falling in the second quadrant, "Personality characteristics of workers" (D6) and "Work experience in construction" (D4) have a relatively high importance and low explanatory power. The impact of personality on the communication outcomes of construction employees has been investigated in existing studies. Personality characteristics play a fundamental role in explaining communication behaviors (Leung and Bond 2001) and are closely connected to communication style and competence (Vries et al. 2013; Weaver 2005). For instance, introversion has been found to affect both communicative competence and communication apprehension, and self-esteem affects communication apprehension (MacIntyre and Charos 1996). In the construction sector, hope and optimism of construction workers are found to be positively related to communication competence. Optimism negatively affects safety participation, which can be improved by communication competence (He et al. 2019). In light of that, EMWs with different personalities may have different safety communication levels, which need to capture the attention of safety management. The importance of work experience in safety communication aligns with Hare et al. (2013) in that the length of construction workers' work experience affects the understanding of safety materials, and experienced workers are better at identifying safety images. EMWs with construction work experience are more likely to improve their ability to interpret safety information.

As SCFs in the fourth quadrant of WFEM group, "Good emotional state of workers" (D9) and "Providing feedback from workers to management" (D10) have a relatively high explanatory power but low importance. As Dainty et al. (2007) state, psychological stress and tension are strongly related to employee ability to deal with and respond to relevant information and messages. Construction workers at the bottom of the organization are regarded as more susceptible to emotional stress compared to managerial staff (Leung et al. 2012). EMWs are more likely to confront with more stress in a different cultural environment and anxiety coming from the absence of family who are in their hometown. As a key element of theoretical models of communication (Dainty et al. 2007), it is necessary for feedback to be provided by EMWs to managers to ensure two-way and effective communication. The absence of feedback may be due to a fear of being regarded negatively be management, damaged relationships and retaliation (Milliken et al. 2003). In addition, the interviews revealed that EMWs also tend to protect themselves and are afraid of losing their jobs. Interviewees L and N highlighted that a lack of feedback from EMWs resulted in management not knowing the level of the EMWs' understanding of safety and health procedures, rules, and regulations.

5.2. Group 2: Manager-related SCFs (MFEM)

Manager-related factors encapsulated seven factors and accounted for 9.564% of the total variance explained among all SCFs. "High quality of supervisor-subordinate relationship" (D24) has the most explanatory power and importance in the group of MFEM. The quality of the supervisor-subordinate relationship is connected to various individual and organizational outcomes, i.e., communication quality and job satisfaction (Abu Bakar et al. 2010; Sias 2005). Research into supervisor-subordinate relationships suggests that the quality of the relationship influences not only how subordinates decide to communicate with their supervisors, but also what they decide to communicate (Abu Bakar et al. 2010). A poor relationship with supervisors may lead to low interactions and mutual misunderstandings and inhibit workers from reporting hazardous and risky situations. With a high-quality supervisor-subordinate relationship, EMWs are more likely to communicate directly and openly and share their opinions (Sias 2005).

"Relevance and accuracy of safety information provided by safety staff" (D22) and "Building trust within the team" (D21) are in Quadrant II and with a highly important but relatively low explanatory power in the MFEM group. Quality of information - including timeliness, accuracy, and relevance - is also an important aspect of communication. As for relevance, Zaremba (2006) asserts that, for effective communication, the message should be considered as important and relevant by communicators, otherwise it might as well be abandoned. Information quality is found to positively influence the level of satisfaction of workers in communicating with immediate supervisors (Allen, 1996), which may explain the importance of this SCF to EMWs. In terms of building trust, Ochieng and Price (2010) comment that trust is an important element in effective cross-cultural communication in multicultural construction project teams, and a high level of trust within a team can fully integrate a multicultural team, leading to open and honest communication between team members. Distrust and suspicion often exist in multicultural workplaces and building trust between EMWs and their local counterparts and managers within a multicultural team is important. It is reasonable to believe that the EMWs' trust in their team can fuel and boost them to cooperate and express themselves openly.

"Cultural sensitivity and competence of management" (D23) is the only factor in Quadrant IV and has a high explanatory power but relatively low importance in the MFEM group. Improving cultural sensitivity and competence to meet the challenge posed by a more culturally diverse construction workforce is necessary for managers. Employees from different cultural backgrounds may have different communication effectiveness in various aspects (Loosemore and Lee 2002; Xie et al. 2009). Xie et al. (2009) find that high context people communicate more effectively than low context people during nonverbal communication, whereas low context people communicate more effectively than high context people in verbal communication. They also demonstrate that power distance influences the efficiency of communication interaction. Thus, when communicating with EMWs, managers should not rely solely on their own frame of reference, beliefs, or values. Competent managers should be sensitive and respond to cultural discrepancies of construction workers, making adjustments to their behavior to meet cultural expectations (Hackman and Johnson 2013).

5.3. Group 3: Organization-related SCFs (OFEM)

The third group is organization related SCFs and accounts for 7.731% of variance explained among all factors. "Organizational support and concern" (D33), "Not much time pressure for completion of the project" (D34) and "Application of visual or pictorial safety materials" (D27) are in Quadrant I and are considered the most explanatory and important factors in the OFEM group. Employee perceptions of organizational support and concern is a vital antecedent for safety communication (Hofmann and Morgeson, 1999). When EMWs perceive that the organization is actively concerned about and supports them, they will be willing and feel free to raise safety issues and believe that doing this will not lead to negative consequences for themselves. Many construction projects need to be delivered over a short period, resulting in time pressure, and can influence the communication patterns of workers and management. Kelly and McGrath (1985) investigation of the communication patterns between team members under different levels of time pressure, for example, concludes that the participation of crew members is more disproportionate and communication time distributed unevenly as the pressure increases. Additionally, there is evidence that stressful environmental conditions can lead to a more decentralized pattern of communication (Brown and Miller, 2000). Visual safety materials (i.e., visual images, videos, and leaflets) have been increasingly used at construction sites to improve hazard communication, and which is also found to be important for EMWs in the present study. However, visual safety materials to convey safety messages, hazards and controls need to be suitably designed for EMWs. Bust et al. (2008a) suggest that the experiential knowledge and cultural narratives used by workers need to be investigated to identify the visual narratives that are suitable and meaningful for construction workers on multicultural sites. In addition, Hare et al. (2012) find that, although pictorial aids can communicate simple hazards and controls to EMWs, the role of pictorial aids needs to be only a supplement to existing communication approaches and not a replacement.

6. Conclusions

EMWs continue to be confronted with communication problems that affect their safety due to national and cultural differences, an issue to which employers have yet to seriously address. The present study identifies a comprehensive list of communication factors and analyses the criticality, underlying constructs, explanatory power, and importance of SCFs that influence/promote/enhance the safety communication of construction industry EMWs.

6.1. Contribution to the knowledge

The contributions to the body of construction engineering and management knowledge are twofold. Firstly, this study contributes to the body of knowledge on communication by identifying a comprehensive list of communication factors in the construction industry. Previous studies have focused on the roles of communication in improving safety climate, safety behaviors, and safety outcomes of construction workers but not yet comprehensively investigated the influencing factors involved. This study takes a step back to explore the contributory factors of effective safety communication. Despite this research being ethnic minority-specific, a set of 36 SCFs identified via literature review, interview and expert evaluation can be not only used to examine the relative importance of EMW SCFs, but can also be adopted to capture the critical SCFs for both local and EM construction workers in other countries.

Second, this study evaluated the criticality, underlying constructs, explanatory power, and importance of SCFs that influence/promote/enhance the safety communication of construction industry EMWs via a questionnaire survey. Effective safety communication is critical for decreasing occupational near-misses, injuries or fatalities, improving safety climate as well as enhancing safety behaviors. The current study identifies the factors that EMWs perceive to be critical for their safety communication on construction sites. A total of 18 critical SCFs were obtained from 36 EMW SCFs based on the EMWs' perceptions and three underlying groups were further identified. This finding can be adopted to better understand the key issues in EMW safety communication for various stakeholders. Prioritizing SCFs is of great importance to the understanding and improvement of EMW safety communication. Narrowing a wide range of SCFs for EMWs provides stakeholders with the insights needed to the key contributory factors of safety communication, which, in turn, has a positive impact on safety performance. In addition, this study not only reinforces the importance of EMW language and safety training, both of which are well-documented in previous studies, but also reveals that additional factors (e.g., the supervisor-subordinate relationship and the supervisor's leadership style) also influence the effectiveness of EMW safety communication.

6.2. Practical implications

Despite the urgent need for improving EMWs safety performance in Hong Kong and Australia, the government, contractors, subcontractors, and other stakeholders are still finding a better way to achieve it. Safety communication is a major safety challenge for EMWs and effective safety communication leads to improved safety performance and decreased injuries and fatalities. Previous studies have shown that identifying critical factors affecting a problem is vital to improving professional practice in the industry. The limited previous research into safety communication mainly identified several a few EMW SCFs. This research provides extra information on the key issues of safety communication that associated stakeholders need to address for EMWs to help them understand and mitigate the main safety communication barriers. Apart from some measures (e.g., language courses, understandable safety training and safety materials, and bilingual translators) that have been taken for improving EMW safety communication in many countries, based on the findings in this study, governments and employers are recommended to adopt multi-faceted strategies manipulating worker-, manager- and organization-related SCFs that would be more effective than a single measure. The critical roles of managers and organization in promoting EMW safety communication are also emphasized in this study. Future efforts to improve or develop programs or interventions for EMW safety communication can benefit from this study by referring to the critical SCFs to include each aspect of safety communication. Furthermore, the identified critical SCFs will also help industry practitioners diagnose deficiencies in EMW safety management practices. Questionnaires in Urdu, Pakistani, Chinese, and Korean can be used by the government, contractors, subcontractors, and other stakeholders to periodically evaluate the factors affecting

EMW safety communication and identify which key safety communication factors to enhance. Despite this study being conducted in Hong Kong and Australia, its findings can also be used as a reference for other countries where EMWs are employed (e.g., the United States., the United Kingdom, Canada, the Middle East, Malaysia, Singapore, and South Africa).

6.3. Practical recommendations

To improve the effectiveness of EMW safety communication, practitioners need to adopt a joint strategy of simultaneously controlling three groups of safety communication factors, including workers, management, and organization. Special attention needs to be paid to address critical SCFs. Merely focusing on several SC factors may not be an effective way to improve EMW safety communication. Industry practitioners could take advantage of the three groups of identified critical EMW SCFs to diagnose the defects in safety management and an adopt an appropriate joint strategy to overcome potential for EMW safety communication impediments. For instance, in terms of management related SC factors, a high quality supervisor-subordinate relationship and trust within teams need to be cultivated. Management needs to improve its cultural sensitivity and competence and not rely on its own frame of reference when communicating with EMWs. The communication style of management and the amount of safety information needs to be appropriate to EMWs. Although local management is unable to communicate with EMWs in their native languages, they need to consider the limited language ability of EMWs and try to avoid too much technical terminology and difficult words. In addition, it would be beneficial for management to listen carefully and actively to what EMWs express, such as concerns, opinions on various issues, and needs. As for organization-related SC factors, the most important is for organizations actively to demonstrate and convey their support and concerns to their EMWs, avoid of putting too much time pressure on EMWs, and adopt some visual or pictorial safety materials onsite. Furthermore, EMWs would benefit greatly from adequate and appropriate safety training and the presence of safety staff from EM's origin.

6.4. Limitation and future research recommendations

Notwithstanding the contributions of the present study to enriching the knowledge of safety communication, it has threefold limitations. First, the study is limited by its use of a non-probability sampling method instead of random sampling to collect data from EMWs, although such measures as achieving a high level of diversity of respondents and avoiding clustering within specific construction sites helps in ameliorating this. The second limitation is that this study focuses only on EMWs. How EMW SCFs associate with cultural differences or ethnicity is unclear. How differently EMWs and local workers perceive the safety communication factors still needs to be further investigated. To achieve this, the perceptions of local workers on SCFs can be captured by the same questionnaire and the differences in relative importance of SCFs can be obtained. Future research can also replicate this study in other countries where many EMWs are recruited for interregional comparisons. Third, the measurement of the appropriateness, relevance, and accuracy of safety information is lacking. Despite some items have been developed to measure the quality of information, the validity and reliability of these items in measuring the quality of safety information in construction is yet to be tested.

Data Availability Statements

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

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Figures and Tables

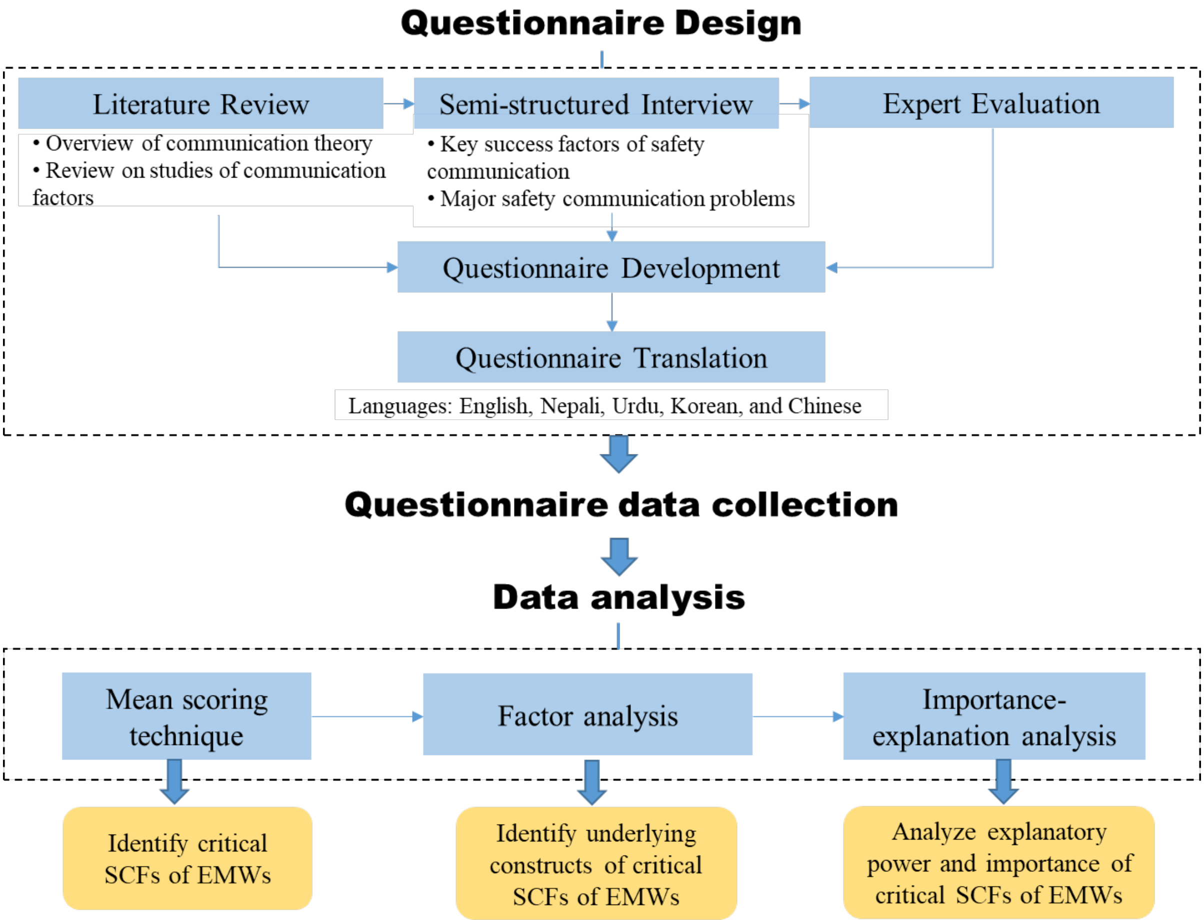

Fig. 1. Research method

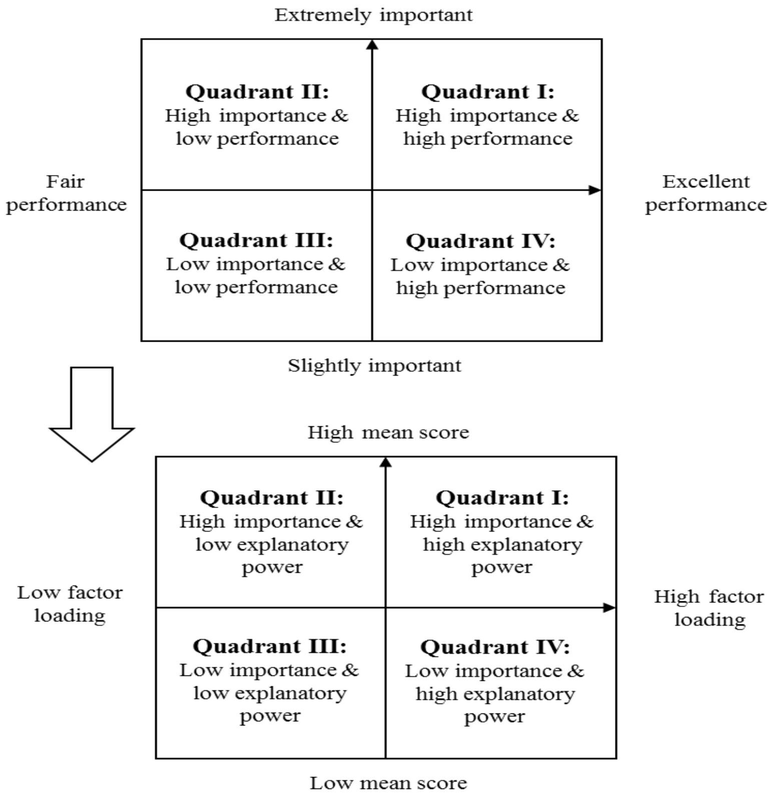

Fig. 2. Importance-explanation analysis

Note: This figure is adapted from Chou et al. (2012).

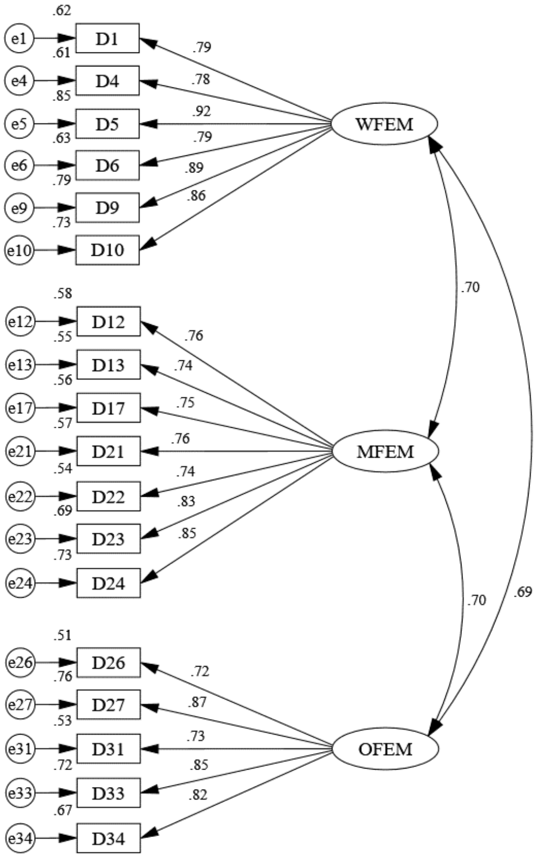

Fig. 3. Model of critical SCFs

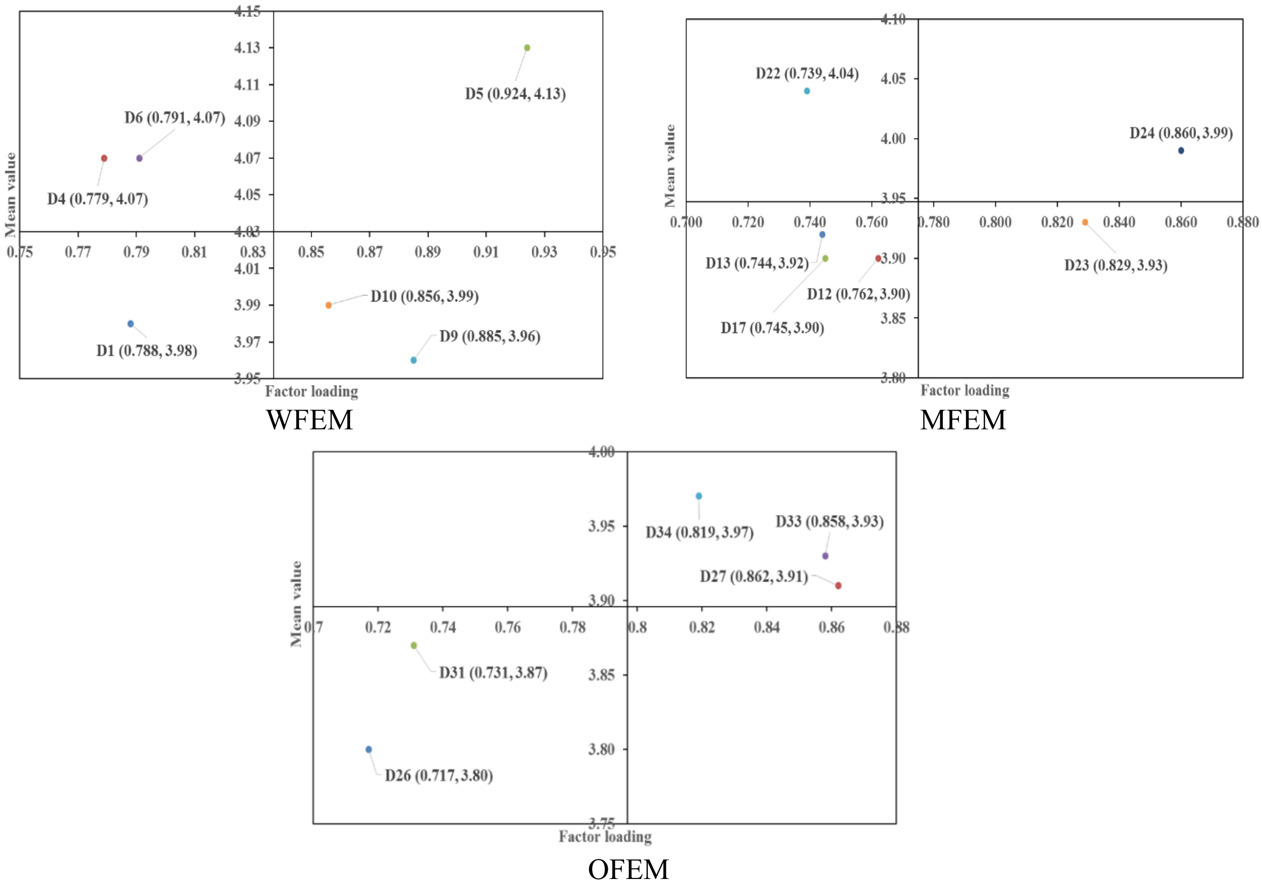

Fig. 4. Importance-explanation analysis of groups WFEM, MFEM and OFEM

Note: The horizontal axis reflects the standardised factor loading coefficients (β) of items, while the vertical axis represents the mean values (M) of items.

Table 1. Communication factors derived from the literature review

Communication factors	Literature in construction sector	Literature in other sectors
1. Adequacy of workers' understanding of culture in host country	[4] [9] [18]	[12] [10]
2. Educational level of workers	[4] [24]	[28]
3. Cultural and ethnical background of workers	[4] [6] [18]	[8] [29] [30]
4. Adequate work experience	[3] [18]	[12] [16]
5. Language ability of workers	[6] [13] [21] [24]	[19] [10] [12] [25] [29]
6. Personality characteristics of workers	[3] [4] [21]	
7. Age of workers	[6] [20]	[10]
8. Drinking habits of workers	[20]	
9. Stress and emotion of workers	[4]	[25] [28]
10. Not pretending to understand		[10] [17] [28]
11. Providing feedback from workers to management	[3] [18]	[19]
12. Appropriateness of language used by management	[18] [23]	[8] [16] [25] [29] [30]
13. Appropriateness of communication style of management	[4] [11]	[25] [29]
14. Avoiding using too much technical terminology and difficult words by management		[2] [17] [28] [29]
15. Power or status differences between workers and management	[18]	[26]
16. Appropriateness of the amount of information presented at one time		[17]
17. Adequacy of explanations by management		[16] [17] [25] [27] [28] [29]
18. Active and careful listening of management	[6]	[26] [29]
19. Attitude and mood of management	[3]	[15] [17] [27] [30]
20. Time constraint of communication	[24]	[10] [16] [25] [29]
21. Appropriateness of time when information is provided	[7]	[12]
22. Trust in management	[6] [18] [21] [24]	[2] [26] [28] [29]
23. Relevance and accuracy of information provided by management		[17] [29]
24. Cultural sensitivity and competence of management	[21]	[5] [8] [29] [30]
25. Relationship between supervisors and subordinates		[22] [29]
26. Appropriation of communication channel adopted to convey information	[1] [4] [6] [24]	[14]
27. Accuracy of translation by translator or interpreter		[2] [10] [29]
28. Adequacy and appropriation of formal presentation from upper management	[1]	
29. Adequacy and appropriation of written communication	[1]	
30. Adequacy and appropriation of safety trainings	[1] [20] [21]	
31. Organizational support and concern	[4] [7] [21]	[29]
32. Time pressure for completion of the project	[4] [23]	
33. Composition of construction team members	[4] [7]	
34. Physical environment (e.g., noisy equipment and room layout)	[4] [20] [24]	[25] [28]

[1] Alsamadani et al. (2013a); [2] Browner et al. (2003); [3] Choon Hua et al. (2005); [4] Dainty et al. (2007); [5] Degni et al. (2012); [6] Ejohwomu et al. (2017); [7] Emmitt and Gorse (2009); [8] Fernandez et al. (2004); [9] Hare et al. (2012); [10] Julliard et al. (2008); [11] Kines et al. (2010); [12] Lonie (2010); [13] Loosemore and Muslmani (1999); [14] Lunenburg (2010); [15] Morinaga et al. (2008); [16] Mosen et al. (2004); [17] Park and Song (2005); [18] Preece and Stocking (1999); [19] Rosenberg et al. (2006); [20] Tam et al. (2003); [21] Tone et al. (2009); [22] Van Wieringen et al. (2002); [23] Wong et al. (2004); [24] Gamil and Rahman (2017); [25] Norouzinia et al. (2016); [26] Gao et al. (2009); [27] Morinaga et al. (2008); [28] Park and Song (2005); [29] Paternotte et al. (2015); [30] Tay et al. (2012).

Table 2. Background of the interviewees

No.	Position of interviewees	Nature of organisation
A	Operational Safety Director	Contractor
B	Safety & Environment Manager	Contractor
C	President	Quasi-government
D	Safety Officer	Contractor
E	Director Safety Manger	Contractor
F	Health, Safety and Compliance Support Manger	Contractor
G	Group HSEQ Manager	Contractor
H	Engineer/Safety & Environmental Advisor	Government
I	Senior Manager/Safety & Health	Government
J	Director	Contractor
K	Senior Safety Manager	Contractor
L	Project HSEQ Manager	Contractor
M	Senior HSEQ Manager	Construction material company
N	Deputy General Manager-Safety & Security	Client
O	Consultant	Quasi-government
P	Construction Safety Engineer	Contractor
Q	Director	Contractor
R	Manager-Project Safety	Contractor

Table 3. SCFs identified from the interviews

No.	SCFs	Interviewees
1	Language ability of EMWs	B, C, D, E, G, H I, M, N, O, Q, R
2	**Employment of staff from EMWs' country**	A, E, F, L, M, Q, R
3	Adequacy and appropriateness of safety training	A, C, L, Q, R
4	**Adoption of pictorial or visual safety materials**	B, C, I, M, Q
5	Language and dialect used by management	C, D, L, R
6	Adequacy and appropriateness of written communication	A, I
7	Accuracy of translation by translator or interpreter	J, R
8	Education level of EMWs	K
9	**Adequacy and appropriateness of toolbox talks**	B
10	Providing feedback from EMWs to management	M
11	Appropriateness of communication channel adopted to convey information	I
12	Appropriateness of communication style of management	D
13	Composition of construction team members	A
14	Stress and mood of workers	P
15	Not pretending to understand	M

Note: The interviewees were represented by letters.

Table 4. Demographics information of EMWs

Demographic variables		Frequency	Percent
Location	Hong Kong	76	56.7%
	Australia	58	43.3%
Nationality in Hong Kong	Nepal	29	38.2%
	Pakistan	22	28.9%
	Ghana	10	13.2%
	Nigeria	9	11.8%
	South Korea	6	7.9%
Nationality in Australia	South Korea	38	65.5%
	China	20	34.5%
Age	30 or below	34	25.4%
	31 – 40	67	50.0%
	41 or above	33	24.6%
Employer	Contractor	33	24.6%
	Subcontractor	101	75.4%
Trades	General labourer	45	31.5%
	Concreter	22	15.4%
	Scaffolder	19	13.3%
	Carpenter	17	11.9%
	Plumber	13	9.1%
	Others	18	12.6%
Work experience in the construction industry	< 1 year	24	17.9%
	1 – 5 years	53	39.6%
	6 – 10 years	38	28.4%
	> 10 years	19	14.2%
Length of service with the current company	< 1 year	34	25.4%
	1 – 5 years	34	25.4%
	6 – 10 years	11	8.2%
	> 10 years	55	41.0%

Table 5. Rankings of SCFs and *t*-test with the mean critical results between Australia and Hong Kong

Code	SCF	Mean	Normalised value	Rank	Mean		*t*	*df*	*p*	Mean Difference
					Hong Kong	Australia				
D5	Adequacy of language ability of workers	**4.13**	**1.00**	**1**	4.01	4.28	-1.819	132	0.071	-0.263
D6	Personality characteristics of workers	**4.07**	**0.93**	**2**	4.09	4.05	0.236	100.256	0.814	0.040
D4	Work experience in construction	**4.07**	**0.92**	**3**	3.96	4.21	-1.633	104.690	0.105	-0.246
D21	Building trust within the team	**4.04**	**0.89**	**4**	3.91	4.00	-0.686	132	0.494	-0.092
D24	High quality of supervisor-subordinate relationship	**3.99**	**0.81**	**5**	3.97	4.00	-0.179	132	0.858	-0.026
D10	Providing feedback from workers to management	**3.99**	**0.81**	**6**	3.95	4.03	-0.548	132	0.585	-0.087
D1	Adequacy of workers' understanding of culture in host country	**3.98**	**0.80**	**7**	3.99	3.97	0.144	132	0.886	0.021
D34	Not much time pressure for completion of the project	**3.97**	**0.79**	**8**	3.89	4.07	-0.967	132	0.335	-0.174
D9	Good emotional state of workers	**3.96**	**0.78**	**9**	3.93	4.00	-0.466	132	0.642	-0.066
D22	Relevance and accuracy of safety information provided by management	**3.95**	**0.76**	**10**	4.14	3.91	1.587	132	0.115	0.231
D33	Organisational support and concern	**3.93**	**0.74**	**11**	3.80	4.10	-1.560	132	0.121	-0.301
D23	Cultural sensitivity and competence of management	**3.93**	**0.73**	**12**	3.83	4.05	-1.583	126.778	0.116	-0.223
D13	Avoiding using too much technical terminology and difficult words by management	**3.92**	**0.72**	**13**	3.82	4.05	-1.585	132	0.115	-0.236
D27	Application of pictorial or visual safety materials	**3.91**	**0.71**	**14**	3.83	4.02	-1.089	132	0.278	-0.188
D17	Active and careful listening to workers	**3.90**	**0.70**	**15**	3.84	3.98	-0.950	132	0.344	-0.141
D12	Appropriateness of communication style of management	**3.90**	**0.69**	**16**	3.83	3.98	-1.070	132	0.287	-0.154
D31	Adequacy and appropriateness of safety trainings	**3.87**	**0.66**	**17**	3.86	3.90	-0.226	98.739	0.822	-0.041
D26	Employment of safety staff from workers' origin country	**3.80**	**0.56**	**18**	3.61	4.05	-2.697	132	0.008**	-0.446
D7	Age of workers	3.69	0.42	19						
D35	Appropriate composition of construction team members	3.69	0.41	20						
D2	Sufficient educational level of workers	3.64	0.35	21						
D28	Accuracy of translations of safety messages	3.63	0.33	22						
D16	Adequacy of explanations of procedures, rules and policy by management	3.62	0.32	23						
D18	Good attitude and mood of management	3.58	0.27	24						
D20	Appropriateness of time when safety information is provided	3.57	0.26	25						

D25	Appropriateness of communication channel adopted to convey safety information	3.57	0.26	26
D3	Cultural and ethnical background of workers	3.57	0.25	27
D32	Adequacy and appropriateness of toolbox talks	3.57	0.25	28
D19	Adequacy of time when communicating with workers	3.57	0.25	29
D11	Appropriateness of language used by management	3.56	0.24	30
D15	Appropriateness of the amount of safety information presented at one time by management	3.54	0.21	31
D14	Degree of power or status differences between construction workers and their managers	3.53	0.20	32
D30	Adequacy and appropriateness of written communication	3.52	0.19	33
D29	Adequacy and appropriateness of formal presentation from upper management	3.49	0.14	34
D36	Appropriateness of physical environment	3.46	0.10	35
D8	No drinking habits of workers	3.38	0.00	36

Note: The critical SCFs are highlighted in bold. Two-tailed test; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 6. Rotated factor matrix for PCA of SCFs

Item		Pattern coefficients			Structure coefficients			Communalities
		MFEM	WFEM	OFEM	MFEM	WFEM	OFEM	
Group 1: Worker-related SCFs (WFEM) (eigenvalue = 9.708, % of variance explained = 53.935, cumulative % = 53.935)								
D1	Adequacy of workers' understanding of culture in host country	0.064	**-0.709**	0.103	0.522	**-0.802**	0.531	0.656
D4	Work experience in construction	-0.194	**-0.893**	0.103	0.369	**-0.840**	0.494	0.730
D5	Adequacy of language ability of workers	0.085	**-0.858**	0.023	0.585	**-0.918**	0.545	0.850
D6	Personality characteristics of workers	0.114	**-0.852**	-0.142	0.522	**-0.839**	0.394	0.719
D9	Good emotional state of workers	0.097	**-0.852**	-0.010	0.575	**-0.901**	0.516	0.818
D10	Providing feedback from workers to management	0.033	**-0.829**	0.064	0.539	**-0.884**	0.543	0.786
Group 2: Manager-related SCFs (MFEM) (eigenvalue = 1.721, % of variance explained = 9.564, cumulative % = 63.498)								
D12	Appropriation of communication style of management	**0.660**	-0.082	0.129	**0.776**	-0.529	0.532	0.624
D13	Avoiding using too much technical terminology and difficult words by management	**0.779**	-0.007	0.003	**0.784**	-0.451	0.428	0.615
D17	Active and careful listening to workers	**0.751**	0.085	0.149	**0.783**	-0.425	0.508	0.628
D21	Building trust within the team	**0.794**	-0.079	-0.068	**0.802**	-0.492	0.405	0.648
D22	Relevance and accuracy of safety information provided by management	**0.866**	0.021	-0.084	**0.809**	-0.424	0.373	0.660
D23	Cultural sensitivity and competence of management	**0.746**	-0.123	0.051	**0.843**	-0.575	0.522	0.725
D24	High quality of supervisor-subordinate relationship	**0.808**	-0.025	0.083	**0.867**	-0.530	0.534	0.758
Group 3: Organisation-related SCFs (OFEM) (eigenvalue = 1.392, % of variance explained = 7.731, cumulative % = 71.229)								
D26	Employment of safety staff from workers' origin country	0.276	-0.077	**0.542**	0.613	-0.535	**0.734**	0.608
D27	Application of pictorial or visual safety materials	0.020	-0.064	**0.851**	0.516	-0.548	**0.897**	0.808
D31	Adequacy and appropriateness of safety trainings	0.145	-0.193	**0.555**	0.555	-0.584	**0.741**	0.605
D33	Organisational support and concern	-0.094	-0.083	**0.901**	0.441	-0.531	**0.897**	0.811
D34	Not much time pressure for completion of the project	0.068	0.103	**0.895**	0.494	-0.433	**0.875**	0.772

Note: Major loadings for each item are shown in bold.

Table 7. Assessment of the measurement model

Fit indices	CFA Model	Level of acceptable fit
Chi-Square Test χ^2/df	2.255	< 3.00
Absolute Fit RMSEA	0.097	< 0.10
Incremental Fit CFI	0.912	< 0.90
Parsimonious Fit PNFI	0.736	> 0.50

Table 8. Factor correlation coefficient and Cronbach's alpha

Groups	Cronbach's alpha	Correlation coefficients			AVE	CR	Mean
		WFEM	MFEM	OFEM			
WFEM	0.932	1.000			0.704	0.934	4.03
MFEM	0.914	*0.694* (0.482)	1.000		0.602	0.914	3.95
OFEM	0.895	*0.684* (0.468)	*0.693* (0.480)	1.000	0.639	0.898	3.90

Note: The values in italics are correlation coefficients of the three components; the values in brackets are squared correlation coefficients.