IMPACT OF STRESS ON INJURY INCIDENTS AMONG CONSTRUCTION WORKERS

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The role of construction workers (CWs), as a group of indispensible, frontline project members, is essential to the success of every construction project. But the job of CW is also recognized as a dangerous occupation. At the same time, because of the physically demanding construction work tasks, crisis-ridden site environments, and the lack of power and control over their work, CWs are 1.7 times more likely to suffer from stress than workers in other industries. Such stress not only affects worker productivity, but also safety at work. Although the relationship between stress and performance has long been validated, studies have rarely investigated that between CW stress and injury rates, which are the ultimate indicator of safety performance. The current study thus aimed to investigate the curvilinear relationships between stress and CW injury incidents. To do so, a questionnaire survey was designed and distributed to CWs in Hong Kong. Three types of stress were identified, including work stress, emotional stress, and physical stress. A structural equation model, developed based on correlation analysis results, indicated that (i) work stress had a U-shaped relationship with the CW injury incidents, (ii) emotional stress also had a U-shaped relationship with the CW injury incidents, and (iii) physical stress had a ∩-shaped relationship with the same. In line with the study results, a number of recommendations are suggested for construction industry stakeholders to minimize injuries incidents among CWs through managing their stress levels appropriately.

Keywords: construction workers, emotional stress, injury incidents, physical stress, work stress.

INTRODUCTION

Safety has always been a major issue in any industry, and particularly in the construction industry. Construction is actually notorious as a high-risk industry (Health and Safety Executive, 2006). Construction workers (CWs) in Hong Kong incur a full 79% of industrial fatalities (Labour Department, 2010). The frontline role of CWs in various work trades among construction projects, such as concrete work, plumbing, painting, machine operation, electrical work, carpentry, and so on, is indispensible and critical for the success of a project and the profitability of a construction company (Applebaum, 1999). CW injuries and fatalities represent a significant monetary loss, progress delay, and reputation damage for construction projects and companies. Thus, various studies have investigated the different factors causing CW injuries, including site design and mechanical design (Edwards and

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Nicholas, 2002; Sawacha *et al.*, 1999). But research studying the impact of stress on the safety of CWs remains rare. Stress is indeed closely related to worker safety, since it can diminish worker awareness and compliance with safety behaviors, which is a vital reason for injuries or even fatal incidents (Elfering *et al.*, 2006; Leung *et al.*, 2010). The current study thus aimed to fill this lack and to develop research-based recommendations on minimizing CW injuries through proper stress management.

STRESS AND INJURY INCIDENTS AMONG CONSTRUCTION WORKERS

Working on repetitive and physically demanding tasks in a dangerous site environment with limited power and support from organizations and industry, CWs are more likely to suffer from stress compared with workers in other industries (Petersen and Zwerling, 1998) as well as to have physical stress symptoms, such as musculoskeletal disorders (Holmstrom and Engholm, 2003). But stress management studies of CWs are still lacking. As per previous stress management studies targeting construction personnel (Leung *et al.*, 2008a, 2010), CW stress generally includes three types: work stress, emotional stress, and physical stress.

Work stress occurs when there is inconsistency between one's expected ability and actual ability to deal with a work task (Gmelch, 1982; Leung *et al.*, 2008a). It refers to individuals' cognitive evaluation of the work stressors they face, such as the number of work tasks to be handled (e.g., tons of construction waste to be disposed of by excavator operators), the degree of task difficulty (e.g., electrical workers building up complicated electronic systems for intelligent buildings), and the degree of skills required (e.g., the adoption of non-traditional, environmentally friendly construction techniques). CWs overstimulated by high work expectations that outweigh their ability to cope with them need to put extra effort into their work, which could diminish their concerns and behaviors over safety, making them more likely to be injured (Dryson *et al.*, 1996).

Emotional stress, which often manifests in the form of emotional drain, fatigue, failure to let go of work from one's mind, and so on, occurs when an individual needs to deal chronically with a demanding and stressful job (Goliszek 1992). In extreme situations where individuals suffer from emotional stress, emotional exhaustion can occur, in which they may depersonalize themselves and lose the ability to devote themselves to their work (Cordes and Dougherty, 1993). Poor emotional states interfere with an individual's alertness and focus on safety measures and behaviors, which are the critical causes of injury incidents (Elfering *et al.*, 2006; Zohar, 2000).

Physical stress refers to an individual's physical adjustment in response to chronically stressful situations. It is thought to have great impact on CWs compared with workers in other industries. CWs are required to be equipped not only with technical skills, but also with a great deal of physical strength for demanding construction tasks, such as fixing large-scale heavy building components, flexibly mobilizing in a rugged and dangerous site environment, bearing extreme outdoor weather, and so on. If the stressful situation continues to affect the individual, the physical adjustment persists, resulting in headaches, back pain, sweating, skin problems, and so on (Mellner *et al.*, 2005). For instance, CWs provided with inappropriate safety equipment at work (i.e., a kind of stressor) have a higher chance of suffering from physical stress (Leung *et al.* 2011). Physical stress further affects the caution and behavior of individuals with respect to safety, subsequently increasing their injury incidents rate (Atkinson, 1999).

Stress, however, is not necessarily harmful (Selye, 1974). Although excessive stress has been found to impair the performance of individuals, (Abramis, 1994; Jamal, 1984), too little stress also has a negative impact on it (Gmelch, 1982). Unlike workers in other industries, the performance of CWs is not limit to productivity and quality. Safety is an essential concern, and the injury incidents rate is often applied to indicate ultimate safety performance (Sawacha *et al.*, 1999). An injury incident refers to any incident causing physical injury to CWs, including being hit by moving objects, slipping, tripping or falling, sustaining injuries while lifting objects, and so on. While facing excessive work stressors, individuals also tend to put extra effort into work tasks so as to speed up work progress and enhance productivity. In such situations, an individual's focus on safety can be distracted, thus increasing his or her chance of being injured (Leung *et al.*, 2010). At the same time, inadequate stress from understimulation can also result in an individual's rustout, which could also lower his or her concentration and caution at work (Varhol, 2000) and, subsequently, increase the possibility of injury incidents. Hence, both too much and too little stress can cause injury incidents among CWs. The current study thus hypothesized the existence of both linear and curvilinear relationships between stress and CW injury incidents.

THE CONCEPTUAL MODEL

Stress is, in fact, inevitable for CWs who work in the dynamic and urgent construction industry. In line with the above literature review, CW stress was hypothesized to have a impact on injury incident rates. Figure 1 illustrates the conceptual model of the three types of stress and injury incidents among CWs.

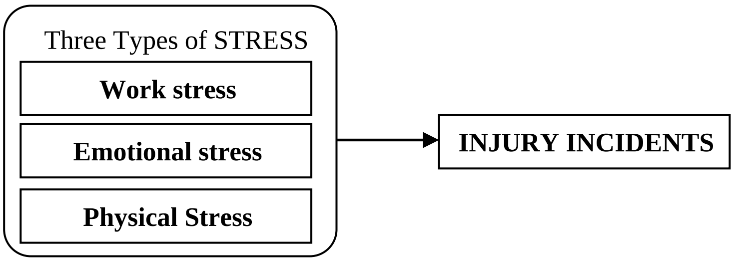


Figure 1: Conceptual Model of Stresses–Injury Incidents among CWs

RESEARCH METHODOLOGY

Sampling

To examine the effects of stress on the injury rate of CWs, a questionnaire was designed and disseminated to CWs in Hong Kong in 2009 using multiple methods, including fax, email, and in person. Out of the 500 distributed, 142 valid questionnaires were returned, representing a response rate of 28.4%. In general, the respondents were aged 41-50 (27.4%), 31-40 (24.2%), and 20-30 (24.2%), with 19% older than 50, and only 4.8% younger than 20. All respondents worked for main contractors (46.7%) or subcontractors (53.3%). In addition, conforming to the reality of the construction industry in Hong Kong, more than 80% of respondents had a secondary education or below.

Instruments

The questionnaire survey was translated into Chinese (the mother language of general Chinese Hong Kong CWs). Respondents were requested to answer the whole questionnaire based on their experience in a particular project they stated at the beginning of the survey. For work stress, the respondents were first invited to rate their actual ability (A) and expected ability (B) on eight task-related statements, such as the number of tasks and the degree of work complexity, using a scale ranging from 1 (none) to 7 (a great deal). The work stress level was then obtained by summing up the difference between the respondents' actual and expected abilities on the various statements (Gmelch, 1982; Leung *et al.*, 2008b, 2010). Second, respondents were invited to rate their degree of agreement with four statements to measure their emotional stress (e.g., "I worry about work during my hours off") and five statements for physical stress levels (e.g., "I often have headaches and migraines") respectively, using a scale ranging from 1 (extremely disagree) to 7 (extremely agree). CW emotional stress and physical stress level were then obtained by summing up their rating on the statements respectively. These two scales have been well validated in previous studies in the construction industry (Leung *et al.* 2008c, 2010).

Lastly, respondents were invited to report the number of injury incidents that had happened to them in the same particular project within two years before filling in the survey (CW respondents in the current study indicated 0 to 5 times of injury incidents they experienced within the timeframe). By injury incidents was meant all incidents that the respondents had had at work that had resulted in an injury. The short two-year timeframe was set to allow for a more accurate estimate (Landen and Hendrick, 1995).

All in all, the CW stress levels and injury incident rate in the same project period and background were measured respectively in the survey. Instead of asking CWs to rate their subjective interpretation towards the impact of stress on their injury incidents, statistical analyses were further conducted to test the relationships between these independent hypothesized variables.

RESULTS

Confirmatory Factor Analysis and Reliability of Stress

Confirmatory factor analysis aims to test and confirm specific hypotheses concerning the structure underlying a set of items (Pallant, 2005). In fact, the three stress scales in the current study has been widely adopted and validated by various previous studies of construction professionals (Leung *et al.*, 2008a, b, c). To further confirm the factor structure of these stress scales in the current study which targets CWs, confirmatory factor analysis was conducted using the software of Lisrel 8.7. The appropriateness of the structural equation model developed is evaluated by the various goodness of fit indices (SAS Institute; 2004). Although four fit indices are usually suggested to quantify the degree of fit of a structural equation model (Kline 1998), six fit indices were included in the current study. The resulting model contained satisfactory model fit indices: 2.11 for the relative chi-square value (x2/df) (should be between 2 and 5 for good model fit; Diamantopoulos and Siguaw, 2000); 0.075 for the root mean square error of approximation (RMSEA) (lower than 0.08, representing a reasonable model fit; Bollen and Long, 1993); 0.92 for the comparative fit index (CFI); 0.87 for the goodness of fit index (GFI); and 0.83 for the relative fit index (RFI) (where the closer the CFI, GFI, and RFI values are to 1, the better the model fit; Diamantopoulos and Siguaw, 2000).

On the other hand, reliability analysis was conducted to ensure the internal consistency of the three stress factors. The most commonly used statistic for this analysis is Cronbach' alpha, which indicates the degree to which the items constitute the scale are measuring the same underlying attribute (Pallnat, 2005). Hence, Cronbach's alpha values were obtained for work stress, emotional stress, and physical stress, resulting in 0.785, 0.920, and 0.871 respectively. Since all alpha values were higher than 0.6, the three stress scales were considered reliable for further analyses in the study (Hair *et al.*, 1998).

Integrated Structural Equation Modelling for Stress and Injury Incidents

Structural equation modeling aims to investigate the interrelationship between a set of dependent variables in a model, to test the overall fit of the model to the data, and to compare the alternative models in the model development process (Pallant, 2005). Hence, to investigate the complicated interdependent relationships between the three types of stress and the CW injury incidents rate, a structural equation model was developed again using Lisrel 8.7. The squares of the three types of stress were also included in the model to allow investigation of the curvilinear relationships between the types of stress and CW injury incidents.

Following the results of the correlation analysis, Model I was firstly developed, with the latent dependent variables of injury incidents (II), and the latent independent variables of work stress (WS), emotional stress (ES), the square of emotional stress (ES2), physical stress (PS), and the square of physical stress (PS2). This model resulted in fit indices of 2.03 for x2/df, 0.075 for RMSEA, 0.93 for CFI, 0.85 for GFI, and 0.93 for IFI. The model was further enhanced by adding the path from the square of work stress (WS2) to injury incidents (II). The relationship between WS2 and II, which was found insignificant in the correlation analysis, is included in the structural equation model. This shows that the relationship between these two variables existed only when considered inclusively with other variables (e.g., CWs may suffer not only from emotional stress, but also from work and physical stress simultaneously). Under a real and inclusive environment (simulated by structural equation modeling), their relationships will be unveiled. This optimized model contained fit indices of 2.06 for x2/df, 0.073 for RMSEA, 0.93 for CFI, 0.85 for GFI, and 0.93 for IFI. Figure 2 shows the final structural equation model of stress types and injury incidents among CWs.

DISCUSSION

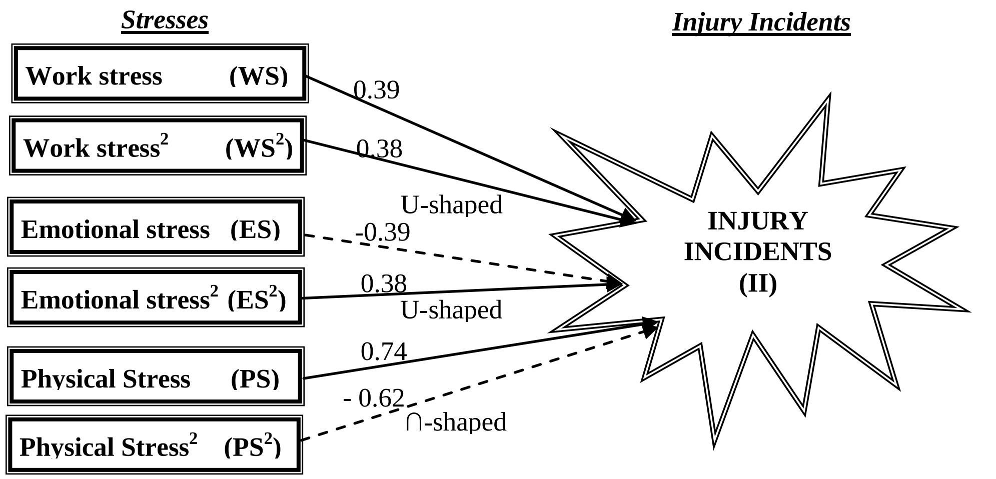
The stresses-injury incidents model indicates that all three types of stress have a curvilinear relationship to CW injury incidents (refer to Figure 2). This demonstrates that, in addition to the physical stress of CWs, which is already a main concern of the construction industry nowadays, their work and emotional stress should also concern the industry. The model also shows that the relationships between CW injury incidents and work stress and emotional stress are U-shaped, whereas that between CW injury incidents and physical stress is an ∩-shape.

U-shaped Relationship between Work Stress and CW Injury Incidents

The U-shaped relationship implies that CW injuries will be on the high side when work stress are too high or too low. This is actually reasonable. CWs suffering from excessive work stress will tend to drive themselves to put more effort into difficult work demands and expectations, such as long and unstable working hours, and heavy and repetitive lifting, which is sometimes beyond their ability. Hence, burnout can easily occur, which would mitigate CW awareness of on-site dangers and of compliance with safety behaviors, resulting in a high rate of injuries. In contrast, rustout will occur if CWs have too little work stress in which their abilities are not fully utilized. In this situation, they might also overlook on-site hazards because of their exaggerated self-perceived abilities. Therefore, to minimize the injury incidents among CWs, it is necessary to maintain work stress at a moderate level.

U-shaped Relationship between Emotional Stress and CW Injury Incidents

A U-shaped curvilinear relationship was also found between emotional stress and the CW injury rate. This implies that too much or too little emotional stress will result in a high number of injuries. Individual CWs suffering from too much emotional stress may be emotionally exhausted from overstimulation and fail to let go of stressful problems from the mind. In such an emotional state, they are more likely to overlook safety behaviors (e.g., focusing less on safety compliance, precautions, and procedures), thus leading to a higher injury rate (Murray *et al.*, 1997). On the other hand, too little emotional stress can mean boredom and frustration to CWs because of understimulation, which could also diminish CW safety behaviors. Therefore, it is important to maintain the emotional stress of CWs at moderate levels in order to minimize their injury rate.



Structural Eqt: II = $0.38WS^2+0.39WS$ (U-shaped) + $0.38ES^2-0.39ES$ (U-shaped) + $-0.62PS^2+0.74PS$ (∩-shaped)

Figure 2: Structural Equation Model of Stresses-Injury Incidents for CWs
Model Fit Indices: x2/df= 2.06; RMSEA = 0.073; CFI = 0.93; GFI = 0.85; IFI = 0.93
Note: ——► / - - - - -► - +ve /-ve causal relationship revealed by SEM.
Numbers above arrows represent standardized path coefficients.

∩-shaped Relationship between Physical Stress and CW Injury Incidents

The ∩-shaped relationship revealed between physical stress and the CW injury incidents rate implies that the lowest rate can be achieved only by extremely high or low levels of physical stress. CWs with low physical stress will be physically energetic enough to handle and give consideration to both construction work tasks and safety behaviors. Thus, they will be less likely to suffer injury. On the other hand, because of the pressing nature of construction projects, CWs are often compelled to work at high speed. This results in their lacking sufficient time to consider thoroughly each action to be taken. They may also easily ignore safety behaviors for the sake of the fast project pace (Choudhry and Fang, 2008). But high physical stress will also weaken their physical condition, which will inevitably lower their work speed. Perhaps it is a slower work pace that leaves them a lot of time to consider work safety, thereby reducing their chance of suffering an injury. At the same time, a high level of physical stress could also lead a CW to stop working, take a rest on the side, or apply for sick leave, which could also explain the resulting low injury incident rate.

RECOMMENDATIONS

To minimize injury incidents among CWs, it is necessary to maintain their work stress at moderate levels. Since the ever-changing construction designs and site conditions throughout the construction process, on-site construction work is often dynamic. To prevent CWs from suffering too much or too little work stress, construction stakeholders were suggested to review the workload and working hours of CWs through regular site meetings. Due to CWs' low status and position within construction projects, they are often excluded from site meetings and receive their work instructions from the participating management personnel only after the meetings. Site meetings, however, could provide a formal, vertical channel for CWs to reflect back to management personnel their actual scope of work, difficulties, and any needs they may have. Management personnel could then assess and reallocate the job responsibilities of various CWs to maintain their job stress at moderate levels.

It is also important to maintain the emotional stress of CWs at moderate levels in order to reduce their injury incident rate. Although the health and safety of CWs are key issues in the construction industry nowadays, their emotional health is often overlooked. To prevent their suffering from too much or too little emotional stress, construction stakeholders were recommended to monitor the emotional stress levels of CWs regularly through a simple questionnaire or short personal interview appraisals conducted by relevant and experienced staff, such as internal human resources staff or external organizational psychologists (Siu *et al.*, 2004). Appropriate emotional counselling could then be provided in time to regulate the emotional stress level of individual CWs, if necessary, before it reaches an extreme.

Although both extremely high and low levels of physical stress were found to predict a low CW injury incidents rate, it would be in vain to increase the physical stress of CWs while simultaneously impairing their bodily health. Therefore, their physical stress is suggested to be lowered and prevented from reaching moderate or high levels. In fact, the needs of CWs are often ignored because of their low status in the construction project hierarchy. For instance, medical support is included in the basic employee benefit package for general construction professionals, but it is rare for CWs to have it. To lower the physical stress of CWs, construction stakeholders were suggested to provide them with medical and physiotherapy support. Regular physical checks and medical and physiotherapy referral schemes, if necessary, could help in monitoring the physical stress of CWs and preventing it from escalating.

CONCLUSIONS

Due to the demanding nature of construction work, a dangerous construction site environment, and the low status of CWs in the industry, construction work has long been recognized as a stressful and crisis-ridden occupation. The impact of stress on employee performance has also been well recognized for a long time. But rarely has the relationship between stress and CW injury incidents, which is the ultimate indicator of safety performance, been studied, still less the curvilinear relationships between them. Thus, the current study has aimed to provide research-based recommendations on reducing CW injury by managing stress levels appropriately.

The study identified three types of stress, namely work stress, emotional stress, and physical stress. A structural equation model for the stresses and injury incidents rates of CWs was developed based on the correlation analysis results. The model indicated curvilinear relationships between CW injury incidents and all three types of stress: work stress (U-shaped), emotional stress (U-shaped), and physical stress (∩-shaped). The results imply that managing appropriately the various types of CW stress is the key to reducing injury incidents rates.

To minimize the number of injury incidents among CWs, construction stakeholders were recommended to (i) maintain the work stress of CWs at moderate levels by reviewing and reallocating their workload through regular site meetings; (ii) maintain the emotional stress of CWs at moderate levels by regularly monitoring their emotional state and providing counseling support if necessary; and (iii) lower the physical stress of CWs by providing them with medical and physiotherapy support.

With reference to 273,400 CWs in Hong Kong (Census and Statistic Department, HKSAR, 2010), the sample size of the current study is relatively small (i.e., 0.05 percent of the total population). However, it should be noted that the respondents of this study were all CWs in Hong Kong who had direct experience with on-site construction work. The study has indicated relationships between CW work stress, emotional stress, physical stress, and injury incidents. This provided a foundation of large scale survey in the future for further validating the current study results.

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