AN INTEGRATED APPROACH TO IMPROVE MENTAL HEALTH AMONG CONSTRUCTION PERSONNEL IN NIGERIA

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An Integrated Approach to Improve Mental Health among Construction Personnel in Nigeria

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CERTIFICATE OF ORIGINALITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgement has been made in the text.

____________________ (Signature)

NWAOGU Janet Mayowa (Name of student)

DEDICATION

I dedicate this thesis to God Almighty and my daughter Gaairu (Flourish) Mercedes Nwaogu.

ABSTRACT

Mental ill-health has been tagged as a silent epidemic in the construction sector. However, despite the increase in mental ill-health within the industry, integrated interventions to ensure a positive response to daily stressors and reduce the onset of the stressors are lacking. While efforts for intervention specific to high-income economies are underway, this study attempted to meet such demand by focusing on lower-middle-income economies using Nigeria as a reference. On this premise, the study aimed to develop an intervention framework for the prevention and mitigation of mental ill-health in the construction industry of Nigeria with a view to improving the health and well-being of construction personnel.

The study aim was achieved by setting out four objectives: identify and assess the risk factors for mental ill-health and protective factors for mental health among construction personnel; assess the effect of work pressure in construction on the physiological health of construction personnel; evaluate potential mental ill-health solutions and develop a mental ill-health prevention and mitigation intervention framework for the Nigerian construction industry. The study adopted the mixed method technique and focused on supervisors and tradesmen. Data was collected using purposive sampling from 174 construction supervisors, 110 tradesmen, and 45 experts. Out of the supervisors and tradesmen, 56 were recruited for an experimental procedure to achieve objective two.

A range of validated psychometric instruments such as the Patient Health Questionnaire, Generalized Anxiety Disorder Questionnaire, and Brief Resilience Scale were employed in addition to self-developed questions to collect data during the quantitative survey. Data from the

quantitative methodology involving questionnaire survey were analyzed using mean score, relative importance index, fuzzy synthetic evaluation, univariate logistic regression, and chi-square, while the experimental data were analyzed using mean and multiple regression analysis. System dynamics modeling and structural equation modeling were used to develop the intervention framework.

Logistic regression deduced that the prevalence rates of depression, anxiety, and suicidal ideation among supervisors were 55.1%, 14.8%, and 9.2%, respectively, and 74.5%, 36.4%, and 14.6%, respectively, among tradesmen. It was deduced that modifiable work-related risk factors include work-home/life imbalance, lack of medical subsidies, and fear of failure. Univariate logistic regression revealed that problem-focused coping strategies are protective against anxiety, as construction personnel who employed skills related to planful problem-solving, positive reappraisal, and seeking social support were less likely to experience anxiety. Resilience was confirmed to be a significant predictor of coping strategy and a moderator in the coping strategy and mental health path.

Heart Rate Variability (HRV) analysis showed that within 150minutes of work schedule, tradesmen and supervisors were subjected to elevated and normal stress intensity, respectively. After which both tradesmen and supervisors had a sleep score of 74% indicating fair sleep quality. Multiple regression showed that HRV data collected within 150mins accounted for approximately 50% variance in the sleep quality. Multiple regression revealed that although construction personnel were subjected to excessive sympathetic nervous activity resulting in an increased need for recovery, proper recovery was disrupted due to intense reduced parasympathetic activities (resting time) during the day. Regarding the intervention strategies (i.e., job resources) to improve mental health in the industry, experts and supervisors indicated that policies that celebrate

employees' success and ensure sustainable retirement plans are most important. On grouping the strategies into constructs, it was also deduced that constructs that motivate employees and build interpersonal relationships were essential. Using modeling and simulation techniques, this research highlighted the need for construction firms to holistically engage primary, secondary, and tertiary intervention strategies that target the organization and individual level for a conclusive mental health and wellbeing outcome. This simulation result suggests that to mitigate and prevent mental ill-health prevalence, risk factors related to job demand need to be reduced by half. In contrast, job control and support factors need to be improved by almost two times to maintain their protective ability. Finally, a mental ill-health prevention and mitigation framework that details an integrated mental health and well-being system was developed and validated. The system will assist in improving mental health in the Nigerian Construction industry. This study recommends that the outlined intervention strategies should form the basis for policy/decision-making regarding appropriate measures to implement in the Nigerian construction industry.

LIST OF RESEARCH PUBLICATIONS AND ACHIEVEMENTS

Some contents of this report are contained in the following articles:

A. Referred Journal papers (published)

1. **Nwaogu, J. M.**, Chan, A. P. C., Hon, C. K. H. & Darko, A. (2019). Review of global mental health research in the construction industry: A science mapping approach. *Engineering, Construction and Architectural Management, 27*(2), 385-410. doi:https://doi.org/10.1108/ECAM-02-2019-0114.

2. Chan, A. P. C., **Nwaogu, J. M.**, & Naslund, J. A. (2020). Mental Ill-Health Risk Factors in the Construction Industry: Systematic Review. *Journal of Construction Engineering and Management, 146*(3), 04020004. doi:https://doi.org/10.1061/(ASCE)CO.1943-7862.0001771

3. **Nwaogu, J. M.,** & Chan, A. P. C. (2020). Evaluation of multi-level intervention strategies for a psychologically healthy construction workplace in Nigeria. *Journal of Engineering, Design and Technology*. doi:https://doi.org/10.1108/JEDT-05-2020-0159.

4. **Nwaogu, J. M.**, Chan, A. P. C., & Tetteh, M. O. (2021). Staff resilience and coping behavior as protective factors for mental health among construction tradesmen. *Journal of Engineering, Design and Technology*. doi:10.1108/JEDT-11-2020-0464.

5. **Nwaogu, J. M.**, & Chan, A. P. C. (2021). Work-related stress, psychophysiological strain, and recovery among on-site construction personnel. *Automation in Construction, 125*, 103629. doi:https://doi.org/10.1016/j.autcon.2021.103629.

6. **Nwaogu, J. M.**, Chan, A. P. C., Naslund, J. A., Hon, C. K. H. & Belonwu, C. (accepted). Exploring the Barriers and Motivators for Using Digital Mental Health Interventions among Construction Personnel in Nigeria: Qualitative Study. *JMIR Formative Research* doi:https://doi.org/10.2196/18969.

B. Referred Conference Paper

1. **Nwaogu, J. M.**, Chan, A. P. C. & Owusu, E. K. (2019). Barriers and motivators to electronic and mobile health (e&mHealth) interventions in mental illness management amongst construction workers. *CIB World Building Congress 2019, 17 – 21 June, Hong Kong SAR*.

2. **Nwaogu, J. M.** & Chan, A. P. C. 2021. Stress-coping strategies among construction personnel: an integrative review. *In:* LARYEA, S. & ESSAH, E., eds. WABER 2021 Conference, 9-

11 August 2021 Labadi Beach Hotel, Accra- Ghana. West Africa Built Environment Research (WABER) Conference, 895-908.

3. **Nwaogu, J. M.**, Chan, A. P. C. & Naslund, J. A. Opinions on Strategies to Improve Mental Health in the Construction Industry. XXII World Congress on Safety and Health at Work, 20-23 September 2021, Toronto-Canada. (Article was Offered Complimentary Registration by Institute of Work & Health, Canada).

C. Referred Journal papers (UNDER REVIEW)

1. **Nwaogu, J. M.** & Chan, A. P. C. (Under Review). Evaluating How Coping Strategies and Individual Resilience affects Anxiety and Depression among Construction Supervisors. *Journal of Civil Engineering and Management* (SCEM-2021-0043).

2. **Nwaogu, J. M.**, Chan, A. P. C. & Darko, A. (Under Review). Risk Factors Influencing Mental Ill-health and Suicide Ideation among Construction Tradesmen in Nigeria. *International Journal of Building and Pathology* (IJBPA-11-2020-0098.R1).

3. **Nwaogu, J. M.**, Chan, A. P. C. & Sunindijo, R. Y. (Under Review). Prevalence and Risk Factors of Mental Ill-health and Suicidal Ideation in the Construction Industry of Nigeria. *Journal of Civil Engineering and Management* (SCEM-2021-0135).

4. **Nwaogu, J. M.,** Chan, A. P. C. & Naslund, J. A. (Under Review). Strategies to improve the mental health of construction personnel based on Expert opinions. *Journal of Management in Engineering* (MEENG-4333).

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LIST OF ABBREVIATIONS

ANS - Autonomic Nervous System

BCI - Brief Coping Inventory

BRS - Brief Resilience Scale

CMD- Common Mental Disorders

EAP - Employee Assistance Program

ECG - Electrocardiogram

EFC - Emotion-Focused Coping

GAD - Generalized Anxiety Disorder

H - Hypothesis

H1 – First Hypothesis in the study

H2 – Second Hypothesis in the study

H3 – Third Hypothesis in the study

H4 – Fourth Hypothesis in the study

HF – High Frequency

HR – Heart Rate

HRR - Heart Rate Reserve

HRV - Heart Rate Variability

JD-R - Job Demand-Resources

LF – Low Frequency

PFC- Problem-Focused Coping (PFC)

PHQ - Patient Health Questionnaire

PPG - Photoplethysmography

RF – Risk Factors

SE – Sleep Efficiency

SEM – Structural Equation Modeling

SI – Stress Index

SMI- Serious Mental Illnesses

TIB – Time in Bed

TST- Total Sleep Time

WCQ - Ways of Coping Questionnaire

CHAPTER 1: INTRODUCTION[1]

1.1 Background of the Study

The construction industry of any nation is strategic to employment and growth. In Nigeria, the construction industry accounts for 20 percent of the nation's employment and 50 percent of domestic fixed capital formation (Olanipekun and Saka, 2019). The industry is time demanding, involves work overload, unrealistic deadlines, dirty and dangerous work environment (Campbell, 2006). These characteristics of the industry have a multiplier effect on a worker's life, which in turn affects an individual's reaction to work and its environments (Turner, 2013, Turner and Lingard, 2016). Specifically, the combination of stressors causes stress to the workers, eventually impacting their health and safety (Kuhn, 2013). Thus, research on health and safety focused on mental health and well-being in Nigeria's construction workplace is expedient for establishing appropriate health promotion measures to sustain the industry's ability to alleviate unemployment, economic challenges and meet sustainable development goals (SDGs 3 and 8).

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[1] The background and research problem aspect of this chapter is partially based upon the following publications:

Chan, A. P. C., Nwaogu, J. M. and Naslund, J. A. 2020. Mental Ill-Health Risk Factors in the Construction Industry: Systematic Review. *Journal of Construction Engineering and Management,* 146**,** 04020004. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001771.

Nwaogu, J. M. and Chan, A. P. C. 2021a. Evaluation of multi-level intervention strategies for a psychologically healthy construction workplace in Nigeria. *Journal of Engineering, Design and Technology,* 19**,** 509-536. https://doi.org/10.1108/JEDT-05-2020-0159.

Nwaogu, J. M., Chan, A. P. C., Hon, C. K. H. and Darko, A. 2019b. Review of global mental health research in the construction industry: A science mapping approach. *Engineering, Construction and Architectural Management,* 27**,** 385-410. https://doi.org/10.1108/ECAM-02-2019-0114.

Nwaogu, J. M., Chan, A. P. C. and Tetteh, M. O. 2021. Staff resilience and coping behavior as protective factors for mental health among construction tradesmen. *Journal of Engineering, Design and Technology*. https://doi.org/10.1108/JEDT-11-2020-0464.

Nonetheless, aside from the workplace stressors, some outside the workplace interfere with them to worsen the situation (Michie, 2002). Therefore, the stressors construction personnel get exposed to are work and non-work-related factors (Langdon and Sawang, 2018, Wang et al., 2008, Wang, 2004, Virtanen et al., 2008). Work factors that impact employees' mental health include psychosocial factors (such as job demand, control, social support, and organization justice), job dissatisfaction, organization change, job insecurity, and employment status (Joyce et al., 2016). The non-work factors include a combination of personal, lifestyle, and social determinants of health factors (Alegría et al., 2018, Joyce et al., 2016, Walker et al., 2004, Wang et al., 2016). Stress causes mental and physiological ill health amongst working populations (Kuhn, 2013, Fan et al., 2015). The physiological (physical) ill-health includes irregular heart rate, cardiovascular diseases (Kuhn, 2013), sleeping problems, relaxation issues (Bowen et al., 2014b, Bowen et al., 2013a); psychological (mental) ill-health include anxiety and depression (Kuhn 2013; Campbell, 2006). Both physical and mental ill-health are detrimental to life (Goetzel et al., 2002). Anxiety and depression are the two most common mental ill-health symptoms (Mnookin et al., 2016) and risk factors for suicide (De Choudhury et al., 2016, Li et al., 2017).

Depression and anxiety are ranked the second and sixth cause of mortality and morbidity disability-adjusted life years (DALY), respectively (Reddy, 2010, World Health Organization, 2017). The working population in construction and other professions conceal mental ill-health because of fear of unemployment and stigma (Burki, 2018, Reddy, 2010), resulting in untreated mental ill-health, leading to high rates of suicide. At the moment the suicide cases in the industry have outpaced musculoskeletal disorder, the suicide rates are alarming, about three times above the national average in the UK (Burki, 2018), 43.6 per 100,000 for the US construction industry

(Peterson et al., 2018). Similarly, in Australia, suicide death amongst men in the construction industry is higher than the general Australian working population (Milner et al., 2017).

According to the World Health Organization (2017), there are approximately 7 million and 5 million cases of depression and anxiety, respectively, in Nigeria. Mental ill-health is seemingly a severe and devastating problem for all countries and economies. In occupational health, mental health challenges constitute the 2nd most abundant category of ill-health (Hunsley et al., 2014). Notably, mental ill-health symptoms do not exist solitary but co-exist (Wang et al., 2016). For instance, depression often co-exists with anxiety, lifestyle attitudes, and other physical health conditions (Kendler et al., 1995).

Mental health refers to the condition of mind, state of well-being, composure in behavior, and actions to persons and the environment in a positive manner (World Health Organization, 2004). Mental health means a positive state of mind that influences positive responses to events and the environment. In contrast, mental ill-health (i.e., poor mental health) can be viewed as a negative response to circumstances and the environment. Mental ill-health affects an individual's perception, reaction, and attitude to things, stress, and the environment (Australian Government Department of Health, 2007). Such poor mental health can negatively affect productivity, performance, safety, physical health, and well-being among working populations (Rajgopal, 2010). Common mental ill health problems include distress, depression, and anxiety (Risal, 2011).

Mental ill-health is synonymous with psychological ill-health (see Sartorius et al., 1996, Wang et al., 2016). The synonym psychological ill-health may be used depending on the sentence construct. Generally, mental ill-health leads to abseentism, presenteeism, lower productivity, and economic losses to organizations and countries (Wang et al., 2016; Hunsley et al., 2014) and work-related injuries (Jacobsen et al., 2013). Due to the nuisance that mental ill-health creates, there is increased emphasis on individual coping strategies and increasing interventions (Langdon and Sawang, 2018; Mnookin, 2016).

Important to note is that the design of a workplace, the culture in place can also influence risk for mental ill-health. Thus, identifying clusters of mental ill-health risk factors which are modifiable signals the possibility of prevention but needs to be shown through context-appropriate intervention studies (LaMontagne et al., 2014). LaMontagne et al. (2014) noted that such studies would help improve the psychosocial quality and reduce work factors that cause mental ill-health. The improvements can positively improve health and well-being since other diseases arise due to job stressors. As such, to reduce the adverse health and economic impact of mental ill health in the construction workplace, individually or in other contextual settings, it is needful to reinforce research into the mental health of construction personnel.

1.2 The Research Problem

In Nigeria, the most populous African nation, mental ill-health results from socio-economic problems, with alarming statistics (Oyewunmi et al., 2015). According to Oyewunmi et al. (2015), there is a need for cultural re-engineering about mental health and promotion of the psychosocial environment in the Nigerian workplace. This makes studies into workplace interventions necessary, as Nigeria's maturing economy is heavily dependent on the active workforce to sustain growth and development. In the construction industry, too much work, work pressure, conflicting demands, lack of feedback, inadequate staffing, poor communication, and lack of privacy are some identified sources of stress among construction professionals in the UK (Campbell, 2006). Campbell's study further reported a high prevalence of stress (61.9%), anxiety (48.4%), and depression (18.5%) among the professionals. In Nigeria, tight budgets, time frames, high volume of work, uncomfortable site offices, and lack of feedback were identified as stress sources to construction professionals (Ibem et al., 2011). Similarly, Oladinrin et al. (2014) identified staff shortage and conflicting job roles as stressors within the construction industry, with depression, hopelessness, helplessness, maladaptive coping behaviors as the impact of such stressors.

According to Ibem et al. (2011), tight budgets and time frames were identified as top sources of stress in the Nigerian context due to two reasons. First, employers within the Nigerian construction industry, mostly expatriates, want excellent delivery in return for their investment. Second, the construction personnel subject themselves to overtime in the quest for extra pay. Therefore, construction professionals in Nigeria view length of work as a stressor because it is compulsive and not cultural. Unlike in countries such as Hong Kong, where construction personnel are willing to work extra hours for cultural reasons (Leung et al., 2014, Westwood et al., 2001). Research into the mental health of construction personnel in Nigeria is long overdue, following the high prevalence of job stress and worsening socio-economic conditions in the country. Although there are a few studies on stress in the Nigerian construction industry (see Oladinrin et al., 2014, Ibem et al., 2011, Wahab, 2010, Ojo et al., 2019), those on stress reactions are minimal (see Ojo et al., 2019, Oladinrin et al., 2014). Notwithstanding, none of the studies evaluated stress reactions related to mental health (such as depression, anxiety) and physiological health (such as sleep quality).

There have been researches on mental health in the construction industry. Still, most of them considered only the effect of work factors on the mental health of construction personnel and are conducted in developed economies. Of the limited researches, the studies were focused on construction managers/professionals (Bowen et al., 2013a, Bowen et al., 2014b, Kamardeen and Sunindijo, 2017, Leung et al., 2014, Love et al., 2010, Sunindijo and Kamardeen, 2017), construction tradesmen and professionals (Boschman et al., 2013) and construction tradesmen (Langdon and Sawang, 2018). Love et al. (2010), using psychosocial workplace factors, examined the mental health of construction professionals in Australia. The study deduced that mental health differed with company type, and site professionals suffered poorer mental health. The study further revealed that high job demand and low social support were significant factors inhibiting good mental health. The study concluded that stress management techniques and problem-solving techniques need to be encouraged in construction professionals. However, Love and colleagues did not consider non-work factors which can aggravate mental ill-health. The study did not also probe how stress affects the physiological health of construction professionals.

Leung et al. (2014) examined construction professionals' stress levels through a comparative study between South Africa and Hong Kong. The study was conducted to gain an insight into stress management practices by construction professionals under psychosocial workplace factors. The study concluded that low job control, high job demand, poor interpersonal relationships, and low support were mental health stressors. The study recommended the implementation of social gatherings, proper job allocation, compensation policies in the workplace to mitigate job stress. Like Love et al. (2010), the study did not consider non-work factors that aggravate mental ill-health.

Bowen et al. (2014b) investigated different occupational stress sources and the effects of stress on construction professionals. The study considered demographic features, particularly age and gender, in stress generation and management. The study revealed that age and gender discrimination were reported in the construction industry in the form of harassment, low job control, high job demand, and little job support. Younger professionals are subjected to excessive workload, while bullying, harassment, discrimination arising from salary level and job roles in the workplace were more prevalent among female professionals. The study using structural equation modeling concluded that psychological stress resulted from job demand, job control factors, and most prevalent among younger professionals. Although the study considered confounding factors and work factors as predictors of psychological stress, what is not yet clear is the role of work and non-work factors in influencing the state of mental health.

Sunindijo and Kamardeen (2017) evaluated construction professionals' mental health using a combination of work and non-work factors. Using correlation analysis, it was deduced from the study that female professionals suffered more anxiety owing to bullying, gender discrimination, ethnic discrimination, and harassment. In contrast, among male professionals, work to family conflict caused mental distress. The study concluded that although non-work factors impacted mental health, the top 10 stressors of mental health were related to the work. However, this study, like previous studies (Leung et al., 2014, Bowen et al., 2014b, Love et al., 2010), was based on only construction professionals and did not consider tradesmen.

Langdon and Sawang (2018) evaluated the mental health of construction tradesmen in Australia using work and non-work stressors. The study revealed that both factors were interrelated. Concerns about the cost of living, job demand impacting on time spent with family and leisure were identified as mental health stressors. The study explained that although tradesmen in Australia are not low-income earners, concerns about keeping up with financial demands impact their mental well-being. A vacuum remains unfilled by Langdon and Sawang, as the study did not evaluate the impact of the stressors on mental health. Although the two latter studies (Langdon and Sawang, 2018, Sunindijo and Kamardeen, 2017) evaluated depression and anxiety as mental ill-health symptoms, considered non-work factors, the impact of family relationships recommended by Wang et al. (2016) was not considered.

Young (2016) evaluated the effect of working hours and work-life balance on the mental health of tradesmen in Hong Kong. The study concluded that construction workers were subjected to long working hours and poor work-life. The study did not conduct the cause and effect amongst the different variables and acknowledged that further research should be carried out to investigate characteristics contributing to work-life imbalance and mental health of construction workers in Hong Kong. Oladinrin et al. (2014) examined stress management in the Nigerian construction industry and found that the itemized impact of stress on professionals included depression and feeling of helplessness (mean score = 3.18), worsening of anxiety (mean score = 2.88), and increase in health-related problems (mean score = 2.85).

With regards to stress responses and the mental health of construction personnel in Nigeria, Oladinrin et al. (2014) remain a teaser, as the study never evaluated the mental health of construction personnel in detail. Based on the previous studies in the region, little is known about the mental state of construction personnel, what factors influence their mental health and well-being, the necessary interventions needed to curb mental ill-health to ensure mental fitness and a psychologically safe workplace. Additionally, there is yet to be developed a workplace mental health intervention developed for the construction industry. Thus, most of the studies on stress and/or psychological health in the construction industry recommended the need for developing an intervention for the industry (Bodner et al., 2014, Langdon and Sawang, 2018, Sunindijo and Kamardeen, 2017).

1.2.1 The Statement of Research Problem

Altogether, while there is a plethora of studies regarding stress in the construction industry, little empirically published studies exist on the mental health of construction personnel in the construction industry. Of these few empirical evidence, studies that have researched the mental health of construction personnel in Nigeria are not readily available. Thus, there is a dearth of research regarding mental ill-health in Nigeria's construction industry, where employee dissatisfaction resulting from poor working conditions, low staff support, high workload, and low income are prevalent (Nwaogu et al., 2016, Abdullah et al., 2011). Previous studies concerning mental health in the construction industry were conducted in developed countries. However, only a few studies considered the impact of firm size and organization structure on the mental health of construction personnel.

In addition, of all the empirically published research on mental health, there is a dearth of studies that have considered designing a mental ill-health intervention for the construction industry, particularly Nigeria. Additionally, of the previous studies, none considered the relationship between construction job roles, work pressure and mental health, the effect of organization structure on mental health, and protective factors for mental (psychological) ill health among construction personnel. So far, none of the previous studies in the subject area evaluated the impact of work pressure on physiological health using objective means.

Based on the preceding, this study attempts to address the gaps identified by providing answers to the following questions:

(i) what are the risk factors for mental ill health and protective factors of mental health among the construction personnel subpopulations?

(ii) how does work pressure in construction affect the physiological health of the construction personnel?

(iii) what are the potential mental ill-health solutions unique to the construction industry in the study area?

(iv) which mental ill-health prevention and mitigation framework will best meet the mental health need of the construction personnel?

1.3 Aim and Objectives

The study aims to develop an intervention framework for the prevention and mitigation of mental ill-health in Nigeria's construction industry with a view to improving the health of construction personnel. The specific objectives are to:

(i) Identify and assess the risk factors for mental ill-health and protective factors of mental health among construction personnel;

(ii) Assess the effect of work pressure in construction on the physiological health of construction personnel;

(iii) Identify and evaluate potential mental ill-health solutions for the construction industry;

(iv) Develop a mental ill-health prevention and mitigation intervention framework for the Nigerian construction industry.

1.4 Significance of the Study

The mental health and well-being of employees is a growing concern worldwide. Presently, industrialized countries of the world have grappled with heightened mental ill-health and suicide rates, with the construction industry ranking top five. The question arises that if industrialized countries with high income suffer from such an epidemic, what then is the Nigerian case following increased job dissatisfaction? In the Nigerian construction industry, employee dissatisfaction and high turnover intention are prevalent, resulting from stressors such as poor working conditions, low staff support, high workload, and low income (Abdullah et al., 2011, Nwaogu et al., 2016). Preliminary evidence shows that depression is high within the Nigerian construction industry, as the mental ill-health symptom ranked second topmost reaction to stressors faced by professionals in the industry (Oladinrin et al., 2014). It is important to note that mental health cannot be divided from general health and well-being (Lehtinen et al., 2005). For instance, Rozanski (2016) opined that job stress, mental distress, alongside other social determinants (marital strain, poor social support, and socio-economic status), causes cardiovascular diseases. Therefore, this study is timely as it will help ensure a healthy, productive, safe workforce, satisfied employees, and achieve reduced medical spending by organizations and individuals.

This study will provide more understanding of the clusters of modifiable risk factors that impact construction personnel's mental and physical health and design an integrated intervention system to prevent and manage mental health. Additionally, the study will inform intervention strategies that will better mitigate mental and physiological ill-health in the construction industry.

1.5 Scope of the Research

The study is restricted to site supervisors and tradesmen engaged with contracting firms undertaking civil engineering projects, real estate property development, and other building construction projects in Abuja and Lagos State, Nigeria. Although some data were collected from experts, the data collected was to enhance the research aim and objectives. Regarding mental ill-health symptoms, the study considered only anxiety and depression because they are the most common in the working and general populations. Additionally, anxiety and depression are also the easiest to assess in non-clinical research settings using self-report questionnaires.

1.6 Research Methodology in Brief

The research aim and objectives were achieved in four main phases, as shown in Figure 1.1. Each phase entailed activities such as literature review, formulation of aim and objectives, the research design, data collection, analysis, conclusions, and recommendations. The research began with phase one, the foundational phase, which is the backbone of the study. The foundational phase entailed an extensive review of existing literature, which included both published and unpublished documents on stress, coping, and mental health, discussion with the project supervisor and other practitioners in the field of public and occupational health psychology. After this stage, the background of the study, the problem entailing the gap, aim, and objectives were formulated.

Phase two and three involved the achievement of objectives 1, 2, and 3. It entailed a comprehensive review of literature, identification of theories, mental health assessment scales and risk, and protective factors. This stage enabled the identification of a comprehensive list of mental ill-health risk factors among construction personnel and the development of a conceptual framework. Two mental health assessment scales (Patient Health Questionnaire- 9 and Generalized Anxiety Disorder- 2) were identified as necessary tools for assessing the mental health status of construction personnel. Thereafter, the close-ended questionnaire tagged “Questionnaire A and B” referred to as “construction personnel questionnaire” was developed and pilot-tested (see

Appendix I and II). Objective 3 would involve the use of a close-ended questionnaire referred to as “Questionnaire c” and post-survey interview questions.

Phase two and three also entailed the use of experiment procedure to achieve objective 2. Following an extensive literature review, a pilot study was conducted to determine the feasibility of using objective means to collect the required data. The subjective and objective means of data collection were employed to evaluate the effect of work pressure on the psychophysiological health of construction tradesmen and supervisors. Phase three primarily involved data collection and data analysis used to achieve objectives four, while Phase 4 entailed combining the results and recommending a system for mental health and well-being promotion. The framework that details integrated intervention strategies for ensuring psychologically healthy personnel and sleep health interventions for physiological health is referred to as Mental Ill-health Prevention and Mitigation Intervention Framework. In Phase 4, the framework was also validated.

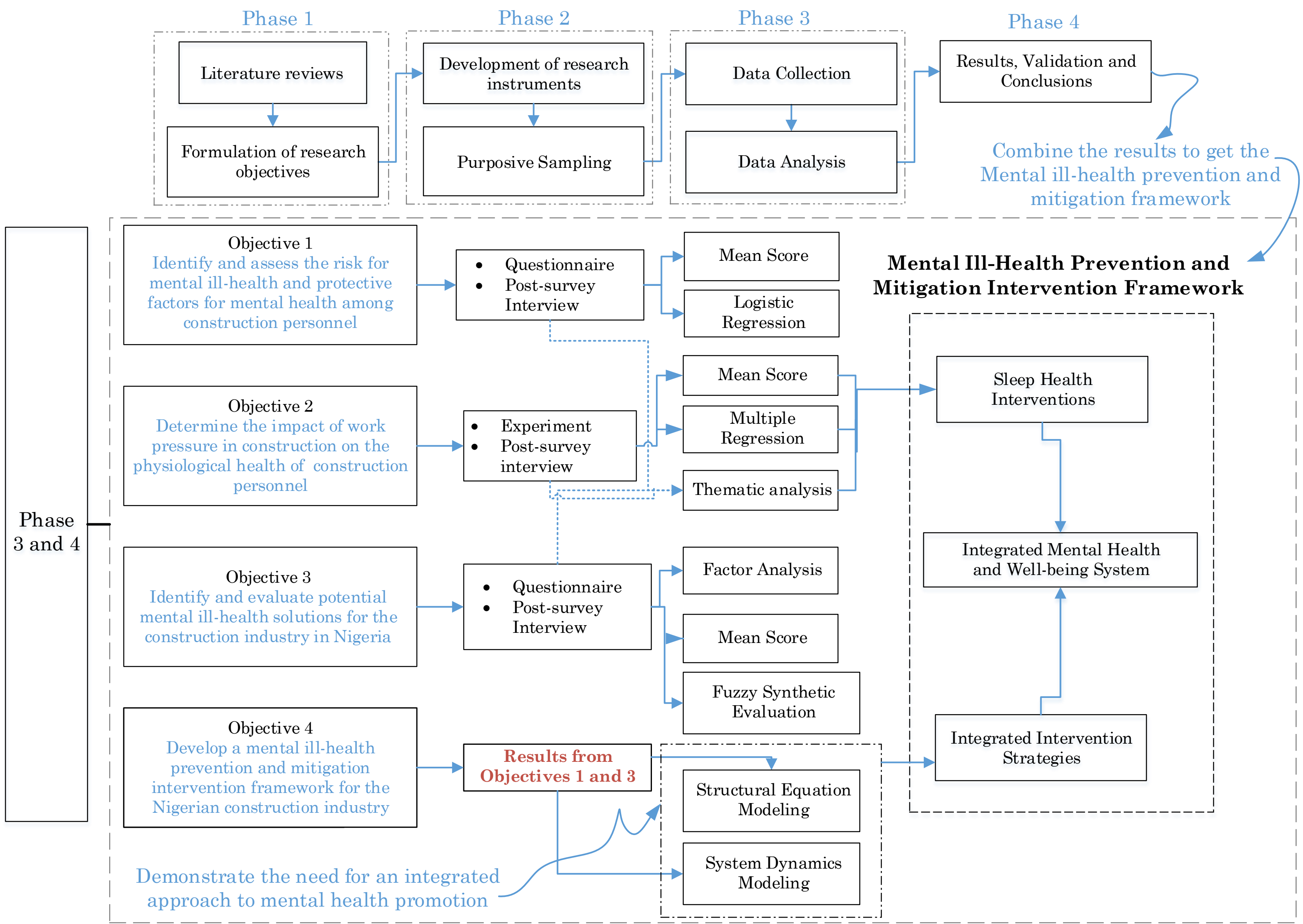

Figure 1. 1: The Research framework

1.7 Structure of the thesis

This report is organized into eleven chapters. Chapter 1 is the introductory chapter; it presents the background of the study, the motivation of the study, and the research aim and objectives. Chapter 2 is the literature review, where extant literature on the aim and objectives of the study are detailed. Chapter 2 discusses the concept of mental health and mental ill-health, risk and protective factors influencing mental health, the impact of work stress on physiological health, and workplace interventions. Chapter 2 ended by detailing existing workplace interventions and the knowledge gap from the reviews. Chapter 3 details the theoretical framework where the theories that underpin the study are discussed. Additionally, the chapter presented the hypotheses and conceptual model for the study. Chapter 4 presents the research methodology, where the sample size, data collection, and statistical analysis methods are discussed.

Chapter 5 details the result of objective one. It discusses the prevalence of depression, anxiety, and suicidal ideation among supervisors and tradesmen. It also highlights the relationship between stressors and mental ill-health symptoms. Chapter 6 focused on protective factors for mental health. In Chapter 6, the role of resilience and coping strategies in mitigating depression and anxiety are reported. Chapter 7 focused on objective two; it outlines results from an experimental procedure used to investigate the effect of work pressure on psychophysiological health. Chapter 8 focused on objective 3; it contains experts' opinion on the intervention strategies for mental health promotion in the Nigerian Construction industry. Chapter 8 and some aspects of Chapter 9 were used to evaluate the potential mental ill-health solutions for the Nigerian Construction industry. Chapter 9 focused on objectives 3 and 4; it details supervisors' opinions on intervention strategies for mental health promotion. It also contains stimulation results highlighting the need to adopt an integrated approach for mental health promotion. Chapter 10 outlines the mental ill-health prevention and mitigation intervention framework and its validation, and finally, the research is concluded, and recommendations for further study are given in Chapter 11. Chapter 11 also highlights the contribution and limitations of the study. Overall, Chapter 5 to Chapter 9 details the data analysis and discussion aspect of the research thesis.

1.8 Definition of Terms

Construction personnel - In this research, construction personnel refers to site-based personnel engaged in supervisory positions (as site supervisors, site engineers, construction project managers) and tradesmen.

Expert - refers to a construction professional occupying decision and policy making roles in the industry.

Job crafting - Is an individual level activity that involves the employee deciding how and when to shapen his or her job task and interaction.

Job sculpting - Is a process that matches an employee to a job responsibility that allows the employee to express his or her deeply embedded life interest.

Mental health - refers to the state of well-being, composure in behavior that makes a person, respond positively to the environment or people (World Health Organization, 2004).

Mental ill-health – refers to the condition of mind that negatively affects the perception, reaction, and attitude of an individual to things, stress, and the environment (Australian Government Department of Health, 2007). Common mental ill-health symptoms include distress, depression, and anxiety (Risal, 2011).

Supervisor: Is an example of a managerial occupation in the construction industry. A supervisor refers to an employee engaged in a managerial role on a construction site and saddled with the responsibility of site management. The nomenclature of description in the workplace may include site supervisor, site engineer, or construction project manager.

Tradesmen: Are personnel on construction sites engaged in manual skills, also referred to as skilled labor such as bricklayers, carpenters, electricians, decorators, etc.

1.9 Chapter Summary

This chapter began with the background to the study, followed by the problem statement, which elucidates previous knowledge in the research area and the gaps identified. It also presented the research questions which need to be answered by the research aim and objectives. The scope of the study and the need for the study were also explained in this chapter. The succeeding chapter (Chapter two) discusses the literature review.

CHAPTER 2: LITERATURE REVIEW

2.1. Preamble

In this chapter, the concept of mental health and social determinants of health is discussed. The existing literature on risk and protective factors within the construction industry and workplace interventions are discussed. Similarly, in this chapter, the effect of work stress on physiological health is elucidated.

2.2 The Concept of Mental Health

The concept of mental health is ever-evolving (Solin, 2011) and includes self-efficacy, autonomy, competence, realizing intellectual and emotional potentials (World Health Organization, 2003). Its importance is synonymous with physical health (World Health Organization, 2003). Both mental health and physical health are mutually exclusive and enjoy a symbiotic relationship (Public Health Agency of Canada, 2006). According to Lehtinen et al. (2005), “mental health is an indivisible part of general health and well-being.” Although mental health is an old term, it is often misunderstood by a lot of people. People tend to think of mental ill-health as mental health.

Mental health is the condition of well-being in which a person can cope with the stressors of life or work effectively, fruitfully, productive, and contribute to his or her community (World Health Organization, 2001). Herrman and Jané-Llopis (2012) defined mental health in terms of coping as the ability to deal with everyday stressors of life. Mental health is the emotional, spiritual strength that makes for enjoying life with the ability to cope appropriately with pain, sadness, and disappointment (Health Education Authority, 1997). According to the Public Health Agency of Canada (2006), "mental health is a definite feeling of emotional and spiritual health that holds equity, justice, interconnections, culture, and dignity."

Following the definition of mental health by these authors and others (see Table 1), it is apparent that mental health's meaning differs from culture to culture. However, one phrase is consistent "the ability of an individual to feel, behave in a positive way." This points to the behavior that is given in response to something, which determines the ability to cope, be resilient or not, and resultant output. Such behavior can be positive or negative depending on interplaying factors (personal, environmental, psychological, and social factors). When the reaction is negative, it tells of mental health problems or mental ill-health.

Table 2. 1: Some definitions of Mental Health

Organization	**Definition**
World Health Organization (2001)	"a state of well-being in which every individual realizes his or her own potential can cope with the normal stresses of life and can work productively and fruitfully, and contribute to his or her community."
Public Health Agency of Canada (2006)	''the capacity of each and all of us to feel, think, and act in ways that enhance our ability to enjoy life and deal with the challenges we face. It is a positive sense of emotional and spiritual well-being that respects the importance of culture, equity, social justice, interconnections, and personal dignity".
Health Education Authority (1997)	"the emotional and spiritual resilience which allows us to enjoy life and to survive pain, disappointment, and sadness. It is a positive sense of well-being and an underlying belief in our own, and others' dignity and worth".
Huber et al. (2011)	"ability to adapt and self-manage oneself." The authors opined that adaptation and management process most times improves subjective well-being and could result in a positive interaction between a person's mind and body."

The difference between mental ill-health and mental health is not clear as people substitute the two terms (Cattan and Tilford, 2006). Lehtinen et al. (2005) opined that mental ill-health points to mental health symptoms, problems, and disorders. Mental ill-health is a health problem that affects an individual's perception, reaction, and attitude to things, stress, and the environment (Australian Government Department of Health, 2007). According to the World Health Organization (2003), mental health problems affect society entirely, not just an isolated segment, so they are a critical worldwide challenge.

Mental ill health does not spare anyone; thus, strengthening mental fitness to ensure mental health is essential. This is to decrease mental ill-health's negative contributions to the community, as mental health is central and fundamental to health. The World Health Organization (2004) stated that "there is no health with mental health," the preposition is used to elucidate the co-existence and interdependence between mental and physical health. Manwell et al. (2015), using the transdomain model of health, gives a comprehensive definition of mental health (see Fig. 2.1). According to Manwell and colleagues, the model explains the interaction of the three (3) determinants of health (physical, social and mental health) and how they could be defined in the concept of mental health.

The transdomain model of health shows the inter-dependence of mental and physical health, how they co-exist and affect the quality of life. The model explains that a standard level of physical health functioning includes an adaptive and regulatory response to psychosocial and socio-economic stress to reduce impact. Alternatively, for mental health, a person's ability to function appropriately with high-level adaptative psychological mindedness would include a sense of optimism and control. Finally, for social health, interdependence on others would help to improve functioning and adaptation. The model highlights that the interaction between physical health and mental health relies on autonomy and making personal decisions with little or no interference.

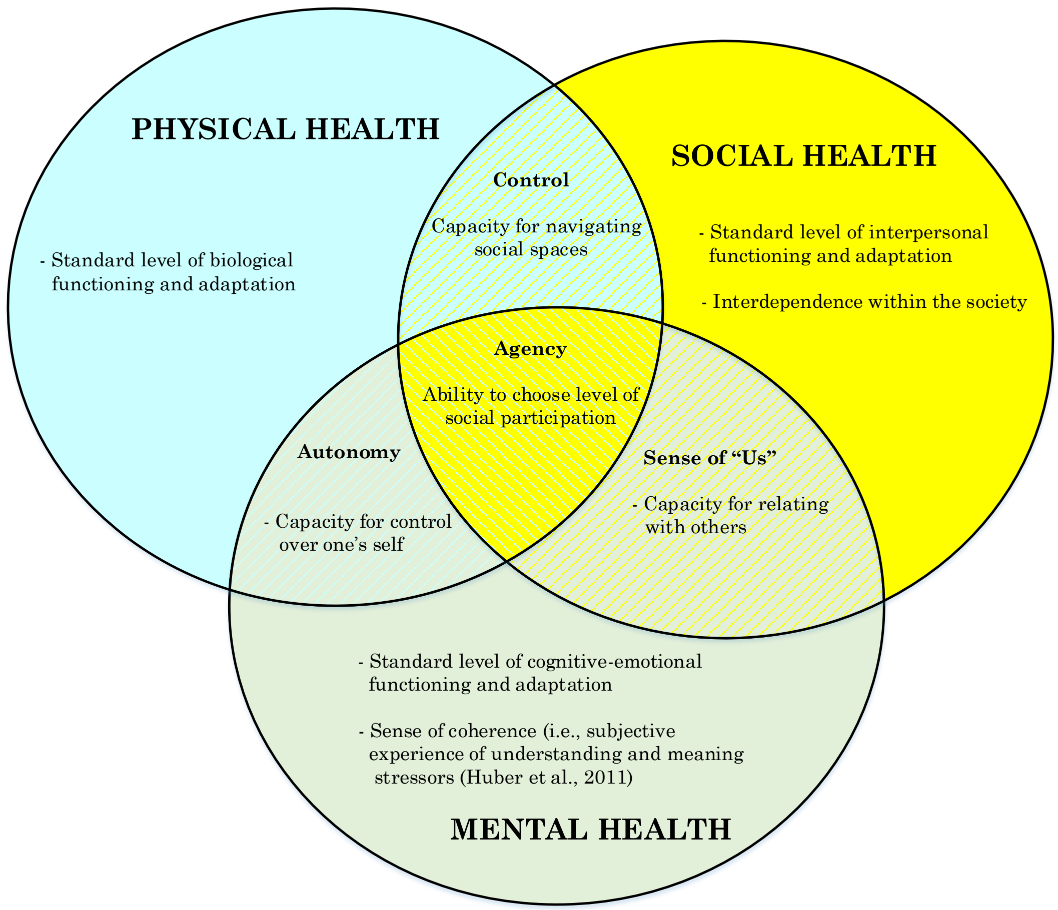

Figure 2. 1 Transdomain Model of Health
Source: Manwell et al. (2015).

Globally, mental ill-health accounts for 1 in 3 causes of disability, 13% of disease, and 450 million people live with it (World Health Organization, 2013, Mnookin et al., 2016). The mental ill-health has caused human misery, as children and adolescents (20%) are also affected (Mnookin, 2016). Herrman and Jane-Llopis (2012) point out that physical health, human behavior, and quality of life are linked to mental health. With strong links between mental health and decreasing harms, positive relationships, reduced use of alcohol and hard drugs, it is expedient to ensure that mental health is improved globally.

In line with ensuring mental health, promotions are called upon across varying populations, gender, and workplace (Manwell et al., 2015, Rebar and Taylor, 2017). Mental health strategies with edging interventions and solutions to mental ill-health are being birthed to ensure adequate mental promotion (Mnookin 2016). Ensuring good mental health is very important as ill-health is an economic cost to both organizations and individuals and affects productivity, turnover, interpersonal relationships, physical health, and social living. For instance, depression (and other mental ill-health symptoms) could disrupt family stability, leading to marital dissatisfaction and separation (Lépine and Briley, 2011).

2.3 Mental Ill-Health

Mental ill-health is of different types and ranges in severity; the most common ones (depression and anxiety) are referred to as common mental disorders (CMD) (World Health Organization, 2014). According to the World Health Organization (2017), CMD refers to a range of anxiety and depression and leads to sizable health and functioning deficits. Less common mental ill-health conditions are referred to as serious mental illnesses (SMI) and consist of psychotic behavior mostly schizophrenia and psychosis (Risal, 2011). According to World Health Organization (2017), common mental health disorders are highly dominant in the population; hence they are considered ‘common,’ they influence the mood or feelings of involved persons; symptoms range in severity (from mild to severe) and duration. The World Health Organization asserts that CMD are diagnosable health conditions and not mere feelings of sadness, stress, or fear that people can experience in their lives.

CMD consists of a group of distress states that manifest with depression and anxiety (Risal, 2011). Sub-threshold mental disorders, which are called "poor mental health," and do not qualify for diagnosis as a mental disorder is experienced by many people (World Health Organization, 2014). Depression and anxiety are ranked as the top global contributors to disability (World Health Organization, 2017). Depression is embodied by sadness, low self-worth, feelings of guilt, sleep disturbance, loss of appetite, and concentration difficulty. It also affects a person's ability to function appropriately at work or cope with daily life. Depression is a top risk factor for suicidality (World Health Organization, 2017, Li et al., 2017, Desjarlais, 1995).

Anxiety is characterized by fear (World Health Organization, 2017), the feelings of nervousness, apprehension, tension, and worry accompanied by physical arousal (Spielberger, 2010). Anxiety can be an emotional state or personality trait (Spielberger, 2010), while anxiety disorder is a group name for mental ill-health with feelings of anxiety and fear (World Health Organization, 2017). Anxiety disorder describes a group of mental disorders, including generalized anxiety disorders (GAD), panic disorder, obsessive-compulsive, phobias, social anxiety disorder, and post-traumatic stress disorder. Of the different types of anxiety disorders, the most common is GAD (Spitzer et al., 2006). Depression and anxiety are co-morbid, as most people experience the condition concurrently (World Health Organization, 2017). The prevalence of depression and anxiety is about 20% in the USA, 10-20% in Europe, 6.6% (3.9% depression, 2.7% anxiety) in Nigeria, and 7.3% (4.2% depression, 3.1% anxiety) in China (World Health Organization, 2017).

Depression and anxiety could negatively influence health status, the capacity to work, and quality of life (Bar-Sela et al., 2015, Sallis and Birkin, 2014, Saneei et al., 2016). When depression and anxiety symptoms are not attended to promptly and adequately, they may lead to chronic physical illness, suicidality, and mortality (Li et al., 2017, Pavičić Žeželj et al., 2019). According to Joyce et al. (2010), mental health is progressively becoming an essential topic in the workplace. Studies have shown that there is a high prevalence of depression and anxiety among the working population owing to occupational stress (Kamardeen and Sunindijo, 2017, Papathanasiou et al., 2017, Pavičić Žeželj et al., 2019, Nielsen et al., 2013, Zhang et al., 2018). Work and the workplace have been identified as critical social determinants of health (Fisher and Baum, 2010, Joyce et al., 2010, Townsend and Davidson, 1992).

2.4 Influences on Mental Health

According to Herman and Jane-Llopis (2012), modifiable factors that impact mental health can be classified into three (3) essential elements, namely, individual, social, and environmental (cultural and political). Individual factors include emotion regulation, coping abilities, conflict management, and tolerance. Environmental factors include housing, safety, access to good education, good working conditions, justice, and equality. Social factors include secure affective relationships, communication opportunities, emotional attachment, and avenues for participation (Herrman and Jané-Llopis, 2012).

According to Herrman and Jané-Llopis (2005), complex interaction exists between the determinants, behavior, and mental health. For instance, lack of profound employment may result from depression to drug and alcohol abuse, leading to physical disability and loss of employment (Walker et al., 2004). Herrman et al. (2005) asserted that a major risk of mental ill-health is associated with poverty and low education. Desjarlais (1995) argues that mental ill-health is often more prevalent among people with comparative social disadvantage. Factors responsible for mental ill-health include low income, poor housing, the experience of insecurity, stressful work environment, discrimination, unhealthy lifestyle (Desjarlais, 1995), physical ill-health, job insecurity, and hopelessness (Patel and Kleinman, 2003).

Physical ill-health, such as hypertension, has been linked to psychological stress related to occupational and other environmental factors (Esler and Parati, 2004). Poor social support and low work control influence physiological health (e.g., cardiovascular diseases) and mental health (e.g., depression) (Bowen et al., 2013a, Bowen et al., 2014b, Rozanski, 2016, Kopp et al., 2000). This further asserts that mental ill-health is detrimental to physical health. Similarly, Ouakinin (2016) opined that depression, anxiety are psychological risk factors for cardiovascular diseases. Mnookin (2016) points out that improvement in mental health will lead to improved physical health. This further explains that mental health and physical health are connected and depend on one another.

According to Herrman and Jane-Llopis (2005), the World Health Organization's definition of health refers to "a state of complete physical, mental and social well-being." This section has shown that to ensure general well-being, it is crucial to prevent mental ill-health and promote mental health at all levels.

2.5 Health in the Working Population

Stress arising from work is a significant challenge for physical and mental health (European Agency for Safety and Health at Work, 2007). Since physical health and mental health are mutually exclusive, work-related stressors can be a significant determinant of mental and physical ill-health, which also can impact each other. The most researched study area relates to job stress and its effects on the professionals' health status (Papathanasiou et al., 2017). Stressors arising from the workplace have been established as risk factors for mental and physical health problems

(Christensen and Knardahl, 2010, Niedhammer et al., 2007, Nielsen et al., 2013). Stressors in the work environment cause negative physiological, mental, and/or behavioral changes in employees, eventually leading to stress reactions such as diminished health, lowered performance, and job dissatisfaction (Nielsen., 2013).

There have been increased rates of mental ill-health and suicide among the working population (Pavičić Žeželj et al., 2019; Burki, 2018; Langdon and Sawang, 2018). The question that comes to mind would be the similitude in stressors of mental health across all sectors. Stressors to mental health are unique to specific work contexts and tasks. This is due to psychosocial factors unique to workplaces, job position, and task (see Høivik et al., 2009, Zhang et al., 2018, Love et al., 2010). For instance, Nielsen et al. (2013) noted that offshore employees are subjected to prolonged working periods amidst other conditions such as safety hazards and physical stressors. The result shows that work factors specific to occupation play a significant role in determining the state of mental health.

In the construction industry, age and gender discrimination, harassment, physical health (particularly injuries), long working hours, low job control, poor communication between colleagues, low salaries have been found to cause mental and physical ill health amongst construction personnel (see Sunindijo and Kamardeen, 2017, Dong et al., 2015, Bowen et al., 2014b). Importantly, when employees have poor mental and physical health, it results in absenteeism, presenteeism, workplace accidents, and suicidality which can also result in low productivity, poor decision making, and staff turnover (see Hilton and Whiteford, 2010, Sanderson et al., 2007b, Wells et al., 1996). Presenteeism in the workplace can be caused by mental ill health (De Lorenzo, 2013, Sanderson et al., 2007a). Over a decade ago, presenteeism resulting from depression costed the United States of America approximately 151 million workdays lost per annum (Kessler et al., 2005).

Researchers have opined that, although work stressors influence the state of mental and physical health, non-work factors, including personal factors arising from family or relationship pressures and lifestyle habit greatly contribute to the health of workers and therefore should not be overlooked (Langdon and Sawang, 2018, Sunindijo and Kamardeen, 2017, Wang et al., 2016, Wang, 2004, Mrazek and Haggerty, 1994). Such non-work factors that can affect response to work stress and mental ill-health include prior or existing negative life occurrences (Rose et al., 2006). In explaining health outcomes, caution is needed on the reliance on only psychosocial models (Bartley, 2004); thus, the importance of non-work-related factors should be considered.

The non-work factors that impact health include socio-economic status (Bartley, 2004, Bartley, 2016), drug abuse, drinking problem, single parenting and child custody issues (Wang, 2004), state of spousal relationships (Grinshteyn and Wendel, 2016, Weissman et al., 1996). For instance, depression rates are higher amongst separated and divorced people. The next section discusses workplace stress factors (resulting from work factors) and personal factors as predictors of mental and physical health.

2.5.1 Work Stress in the Construction Industry

Work stress is a response to stress arising from workplace psychosocial factors. The National Institute of Occupational Health and Safety (1999) cited in Kuhn (2013) defined work stress as “the harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources or needs of the worker.” According to Ganster and

Schaubroeck (1991), work-related stress is “the inability to cope with the pressure in a job.” Levi (2000) defined work-related stress as “a pattern of emotional, cognitive, behavioral and physiological reactions to adverse aspects of work content, organization, and environment.” The definitions indicate, there is no generalized definition for work stress. From these definitions, it can be explained that work stress arises when the needs of a job or its work environment are beyond an employees’ capacity or control. A mismatch between job demands and pressures on an employee and his knowledge and abilities results in stress (Kuhn, 2013).

Unlike previous authors, Kuhn explained further that stress is not only pressure-related but could arise when an employees’ knowledge and capability are underutilized. Stress challenges an employees’ ability to cope with work. It could occur because worker’s expertise and ability are incapable to meet job demand or due to work pressure of the job task. Construction workers are continuously exposed to such occupational stress that can cause mental ill health, which in turn impairs safety and possibly leading to project failures (Bodner et al., 2014). Leung et al. (2011) reported that among construction workers, job stress precedes burnout, while burnout, in turn, causes physical stress and reduced organizational performance.

In the construction industry, this workplace stress arises majorly from work factors or stressors like workload (Leung et al. 2016), working environment (Hu et al., 2000, Love et al., 2010), organizational culture (Samuel, 2015), poor interpersonal relationships (Sunindijo and Kamardeen, 2017), poor career development (Boschman et al., 2013), discrimination and harassment (Bowen et al., 2013a, Bowen et al., 2014b). Additionally, stressors such as long working hours and work-related injuries cause physiological strain, e.g., concentration problems and sleep problems (Bowen et al., 2014b).

2.5.2 Non-Work Stresses in the Construction Industry

Based on the definition of work-related stresses, non-work stress can be seen as "a response to stress arising from the home, self or other stressors outside the workplace." It could also be the "inability to deal with pressures arising from home, needs, personal life, and status." According to Mrazek and Haggerty (1994; p. 168), non-work stressors of mental health are associated with loss, divorce, marital status (divorce, separation), unemployment, sense of personality (low self-esteem, hopelessness, low self-efficacy), sense of support (helplessness), gender, and welfare status. They also include life events, caring responsibilities, domestic abuse, financial difficulties, poor housing quality, and non-work social support (Clarke et al., 2012). Non-work stressors identified in the construction industry literature include poorly functioning homes (i.e., tense relationships), personal health conditions, low support at home, care needs for family members (Sunindijo and Kamardeen, 2017).

2.6 Risk Factors for Mental Ill-Health and Protective Factors for Mental Health

The section discusses the risk and protective factors for mental health and ways of assessing common mental ill-health in non-clinical populations. In studies related to mental health, understanding the risk factors driving poor mental health (mental ill-health) amongst construction personnel and identifying factors that protect the personnel against mental ill-health are pre-requisite to appropriate intervention development. It is important to note that a stressor may not be a risk factor for ill-health until the cause and effect relationship has been shown. This section details general literature on risk and protective factors already researched in the construction industry.

2.6.1 Risk factors for mental ill-health in the construction industry[2]

Risk factors refer to characteristics or variables that, when present for an individual or group of people, make them more vulnerable to a disease or unhealthy outcome than the general population (Mrazek and Haggerty, 1994 p. 6). Kraemer et al. (1997) described risk factors as measurable characteristics of individuals among a given population that gives rise to an outcome of interest, categorizing the population into high or low risk. Risk factors are interwoven and interrelated to one another, so it is better to develop interventions that will address the constellation (clusters) of risk factors (Mrazek and Haggerty, 1994; p. 46).

There are two significant categories of risk factors, namely causal and non-causal risk factors. Both types of risk factors are predictors but vary based on treatment efficacy (Franklin et al., 2017). They are either modifiable (malleable) or non-modifiable (non-malleable). For this research, only modifiable causal risk factors will be considered and discussed. Workplace characteristics such as working conditions are possible modifiable factors that could be focused on interventions (LaMontagne et al., 2014). Identifying risk factors that are modifiable signals the possibility of prevention but needs to be shown through intervention studies (LaMontagne et al., 2014). Researches on risk factors for mental ill health among the working population have dominated literature because stressors that cause depression and anxiety are culture and context-

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[2] This section is largely based on publications produced by the author of the thesis during the Ph.D. study:
Chan, A. P. C., Nwaogu, J. M. and Naslund, J. A. 2020. Mental Ill-Health Risk Factors in the Construction Industry: Systematic Review. *Journal of Construction Engineering and Management,* 146**,** 04020004. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001771.

specific (see Boschman et al., 2013, Cohidon et al., 2010, Nielsen et al., 2013, Al-Maskari et al., 2011, d'Errico et al., 2011, Sunindijo and Kamardeen, 2017, Chen et al., 2009).

A primary reason for continued research is because the identification of risk factors will inform on what should be eliminated or modified by intervention and what would form the basis for policy development for each context (LaMontagne et al., 2014, Langdon and Sawang, 2018, Rebar and Taylor, 2017). In simple terms, the risk factor refers to an agent (Kraemer et al. 1997). A systematic review of literature that considered stressors in the construction industry and their impact on mental health revealed 32 risk factors of mental ill-health (see Table 2.2). The database of Scopus, Web of Science, and PubMed were visited, and several search strings were employed. The string with the highest output was "mental health*" "construction industry*" "psychological health*."

The initial search generated a total of 107 articles. The articles were checked for repetition; 57 duplicates were recorded and eliminated. Thereafter, the abstracts of 50 remaining articles were read, and those (only 13 articles) that met inclusion were subjected to full-text reading. Three (3) additional articles that fulfilled inclusion criteria were identified from references of the 13 articles, and google scholar was used to retrieving the other articles. A total of 16 articles were employed for the review, from which the 32 risk factors for mental ill-health were deduced. However, risk factors related to demographic characteristics such as age, gender, and marital status could be eliminated, as their influence on mental health can be considered appropriately. This means that the effect of such demographic characteristics on the degree of mental ill-health will be considered separately. Therefore, 29 out of the 32 risk factors are considered alongside other risk factors for this Ph.D. study (see Appendix I and II).

The risk factors are grouped into constructs, and a conceptual framework developed (see Figure 2.2). The following sections discuss the identified risk factors variables. A major shortcoming of the studies on mental health in the construction industry stems from primarily focusing on psychosocial workplace stressors. Only two Australian studies considered risk factors outside the workplace (Sunindijo and Kamardeen, 2017; Langdon and Sawang, 2018). In emphasizing the importance of more research, studies have stated the need for considering non-work stressors. For instance, Virtanen et al. (2012, 2008) opined that to better inform interventions for managing workplace stress and mental ill-health outcomes, it is expedient to explore the relationships between work stressors and a range of non-work stressors.

Similarly, Bowes and Jaffee (2013) opined that there are multiple channels to mental ill-health, necessitating the combination of different risk factors. The effect of risk factors depends on its timing and connection with other risk factors. Bowe and Jaffe explained further that individual factors (ethnicity and culture) might mediate risk factors for mental ill-health, noting that the concept of risk varies from one group or culture to another. For instance, what constitutes child maltreatment in one culture, or at a time in history, differs (Bowes and Jaffee, 2013).

Table 2. 2: Risk factors for mental ill-health identified from the literature

Risk Factors (RFs)	Publications																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Physical illness	x	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-	3
Nature of work / mental demand	x	x	-	-	-	-	-	-	-	x	-	-	x	-	-	-	4
Hours worked per day (Excess of 60hrs per week)	x	-	-	-	x	-	-	-	x	-	x	x	x	x	x	x	9
Low income / Financial insecurity	x	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-	3
Work overload / Quantity of work	x	x	-	-	x	-	-	-	-	-	x	x	-	x	x	-	7
Increased work speed/pressure	-	x	x	-	x	-	-	-	-	x	-	-	-	-	x	-	5
Little opportunity/ability to participate in decision making	-	x	-	-	-	-	-	-	-	x	x	-	-	x	x	-	5
Little social support from colleagues / immediate supervisors	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	-	2
Little relationship with colleagues/co-workers	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	1
Occupational injury/hazards	-	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-	2
Poor working conditions	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	1
Inability to further learning	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Job insecurity (fear and uncertainty about the work)	-	-	-	-	x	x	-	-	-	x	-	x	-	-	-	-	4
Post-traumatic stress	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	1
Fatigue and need for recovery	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Criticisms	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	1
Lack of feedback mechanism in place	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	1
Low socioeconomic status	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	1
Over-promotion concerns	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	1
Poor occupational climate (i.e., task autonomy, responsibility, authority)	-	-	-	-	x	-	-	-	-	x	-	-	-	-	x	-	3
Fear of failure	-	-	-	-	x	-	-	-	-		x	-	-	-	-	-	2
Interpersonal conflict	-	-	-	-	-	-	-	-		x	-	-	-	-	-	-	1
Substance abuse	-	-	-	-	-	-	x	-	x	-	-	-	-	-	-	-	2
Alcohol consumption	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	1
Musculoskeletal pain and injuries	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	1
Poor physical working condition	-	-	-	-	-	x		-	-	-	x	-	-	-	-	-	2
Marital Status	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	1
Gender discrimination	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	1
Lack of respect from subordinates	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	1
Workplace harassment/bullying	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	1
Work-home conflict/life imbalance (lack of time for family and other leisure due to work)	-	-	x	-	x	-	-	x	x	-	-	-	-	-	-	x	5
Age discrimination	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	1

Notes: 1. Al-Maskari et al. (2011); 2. Boschman et al. (2013); 3. Dong et al. (2015); 4. Haynes and Love (2004); 5. Hu et al. (2000); 6. Jacobsen et al. (2013); 7. Kamardeen and Sunindijo (2017); 8. Langdon and Sawang (2018); 9. Lim et al. (2017); 10. Love et al. (2010); 11. Sutherland and Davidson (1993); 12. Sunindijo and Kamardeen (2017); 13. Tsutsumi et al. (2001); 14. Bowen et al. (2014c); 15. Leung et al. (2014); 16. Lingard et al. (2007)

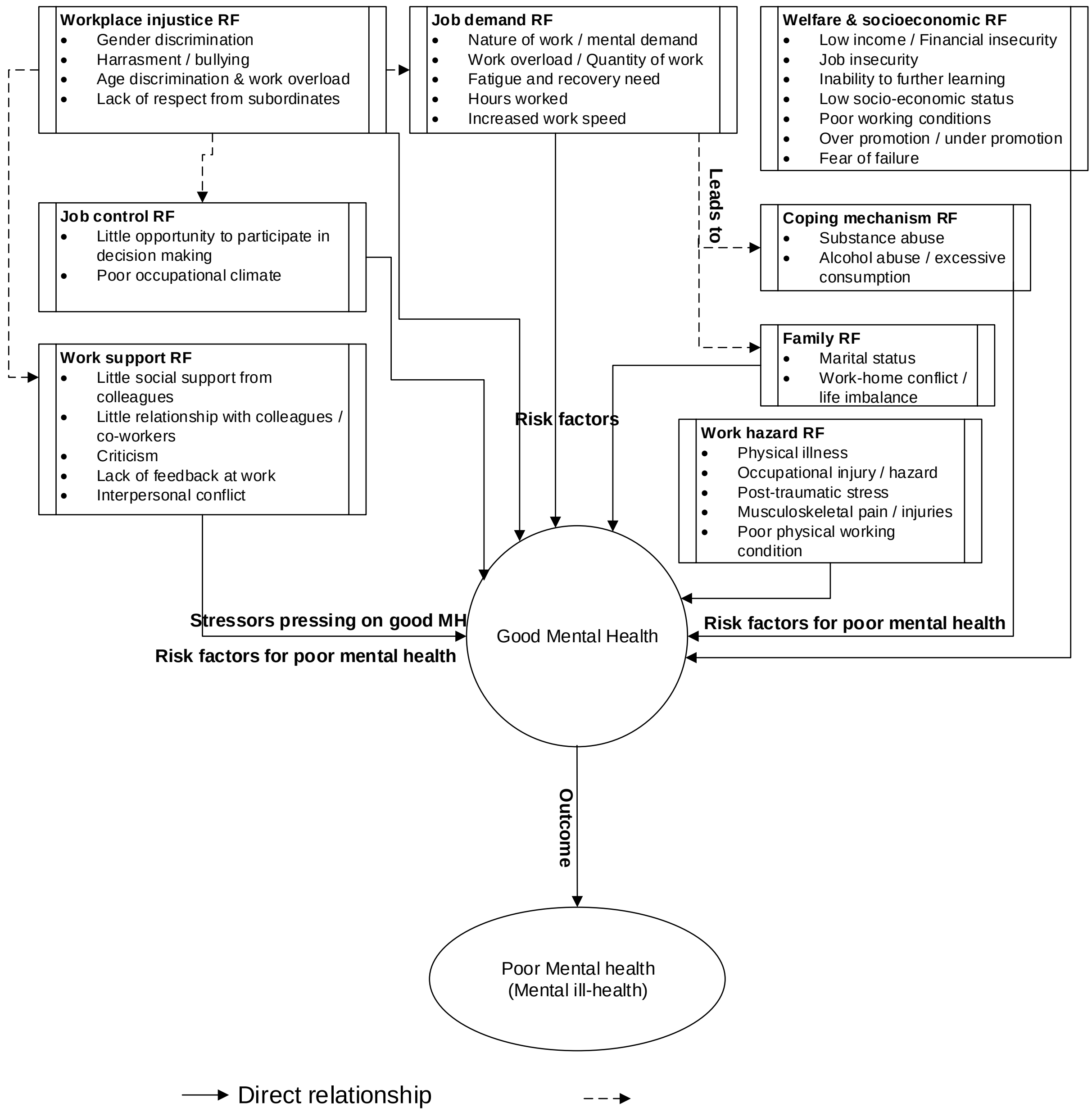

Figure 2. 2 Conceptual framework for mental ill-health risk factors in the construction industry

2.6.1.1 Job control risk factors

Job control, also called the decision latitude, relates to an individual's ability to decide on preferred work activities or control their work activities (Van der Doef and Maes, 1999). Ganster

(1989) noted that job control could influence the work environment making it less threatening and rewarding. This relates to skill discretion and decision authority, ability to make judgments, choose work schedules, and give subordinates orders. The Job Demand and Control (JDC) model emphasizes the place of job control by explaining that job control mitigates stress, increases learning, motivation, and skill development (Karasek, 1998).

Job control entails the ability of workers to participate in decision-making (Cattell et al., 2016), determine working schedule (such as flexitime arrangement) (Joyce et al., 2016), and the ability to take leave (Love and Edwards, 2005). Job control also encompasses the level of authority and responsibility given to an employee (Leung et al. 2014). When employees are not given opportunities to exercise some level of authority and responsibility in their job roles, the feeling of inability to influence their work environment arises and could lead to dissatisfaction and psychological strain. It was deduced from the studies that gender and age influenced the level of control (Bowen et al., 2014b, Bowen et al., 2014a). According to Bowen and colleagues, female and younger professionals reported higher psychological strain associated with low job control.

Construction female professionals are reported to suffer low job control resulting from male artisans' refusal to take instructions from them. Although lack of job control varies according to the type of firm, they are more prevalent in contracting firms (see Love et al., 2010). Job control measures reported were related to occupational climate, office politics, line of authority, and communication path (see Sutherland and Davidson, 1989).

2.6.1.2 Welfare concerns

The review revealed that welfare concerns were related to socio-economic status, job insecurity, low income, fear of financial insecurity, and worries about further learning. Among all the varying grade levels of construction workers, fear of job insecurity was associated with high level of anxiety (Sutherland and Davidson, 1993). Job insecurity was higher among married employees (Lim et al., 2017). This could be linked to worries about how to carter for their families should they lose their job or when the construction project is concluded. Similarly, Langdon and Sawang (2018) reported that fear of financial insecurity did not stem from financial management but fear of catering for a family in the case of unemployment. Depression and suicide ideation were reported associated with low income (Al-Maskari et al., 2011).

2.6.1.3 Work hazards

Construction workers are exposed to occupational illnesses and injuries (Jazari et al., 2018). Based on the nature of construction jobs, especially at heights and manual laborer use, the construction industry has a high number of work-related deaths and high prevalence of musculoskeletal pain (Boschman et al., 2013, Hu et al., 2000). Also, the industry has been reported to have high incidences of work-related diseases such as skin (Bhuiyan et al., 2016) and respiratory diseases (Bock et al., 2003). Following work hazards, exposed workers suffer trauma and can develop post-traumatic stress disorder (World Health Organization, 2003). Likewise, Hu et al. (2000) pointed out that post-traumatic stress disorder (PTSD) could occur after a life-threatening stressor which causes intense fear, loss of control, and helplessness.

Among construction personnel, work hazard-related risk factors were related to physical illness, PTSD, musculoskeletal pain, and occupational injury (Chan et al., 2020). Such work hazard risk factor was associated with depression and anxiety (see Al-Maskari et al., 2011) and mental distress (see Jacobsen et al., 2013).

2.6.1.4 Job demand risk factors

Job demands refer to stressors arising from workload, time pressure, and role conflict(Karasek Jr, 1979). Job demand is related to work that requires a high level of physical and/or mental effort causing mental ill-health such as depression (Cohidon et al., 2010, d'Errico et al., 2011). When job demand is too high, they place strain on family and work-life, eventually leading to reduced family support, especially among construction professionals (Leung et al., 2010). Job demand risk factors are related to the nature of work / mental demand, work overload, hours worked per week, fatigue, and need for recovery (Love et al., 2010; Al-Maskari et al., 2011; Boschman et al., 2013). Young employees and female personnel suffer discrimination and high job demand in the construction industry leading to anxiety, depression, and sociological strain (Bowen et al., 2013).

2.6.1.5 Job support related risk factors

While job support or workplace social support is a protective factor, its absence constitutes a problem. Literature on mental health within the construction industry revealed that low support is a risk factor for mental ill-health. Boschman et al. (2013) found that depression was related to low social support from direct supervisors. Similarly, younger construction professionals were reported to suffer low social support (Bowen et al., 2013b, Bowen et al., 2014b).

2.6.1.6 Workplace injustice

Workplace injustice-related risk factors included gender discrimination, harassment, bullying, age discrimination, and lack of respect from subordinates. Gender discrimination was more prevalent among females because they were often paid a lower salary than their male counterparts (see Kamardeen and Sunindijo, 2017; Bowen et al., 2014). Generally, the review revealed that female professionals more than their male colleagues were subjected to varying forms of harassment, including sexual abuse, verbal abuse, and physical contact. The male subordinates were also more likely not to accept work orders from their female superior, causing low job control and support. All professionals, irrespective of their gender, were subjected to age discrimination, as younger professionals were saddled with more responsibility amounting to the perception of high job demand, lower job control, and low support than their older colleagues (Bowen et al., 2014). Age discrimination was deduced to account for psychological strain. Overall, it was deduced that females than their male colleagues suffered more anxiety and depression.

2.6.1.7 Family

Stressors such as marital status and work-family/life conflict made up the family-related risk factors construct. Among male and female professionals, work demand creeps into family life affecting their ability to keep up with family responsibility. Although marital status was a risk factor, it was reported to have a moderating ability, especially among married professionals (see Kamardeen and Sunindijo, 2017). Personal stress due to marital status (e.g., separated, divorced, widowed, or single) caused anxiety and depression. When non-work stress combines with work stress, the severity of mental health problems among the construction professional is likely to increase.

2.6.1.8 Coping mechanism

High job demand, low work support, and job control have resulted in construction workers employing several coping strategies. The coping strategies can broadly be categorized as positive (adaptive) or negative (maladaptive). For instance, a coping strategy attributed to Alcohol, Drug, and Substance Abuse (ADSA) is used as sources of diversion, to shelve the effect of strenuous work (Frone, 2006). The studies also reported construction workers turning to ADSA (Sutherland and Davidson, 1993), with substance abuse revealed to be associated with anxiety (Langdon and Sawang, 2018). Mushi and Manege (2018) attributed such ADSA coping strategy to the risky or tough nature of each construction trade. Employing negative coping strategy through alcohol abuse may also be linked to the strong drinking culture in the construction industry (Roche et al., 2015). However, ADSA as a coping strategy is negative, as prolonged use of ADSA has been linked to increased risk of job safety (Minchin Jr et al., 2006). Additionally, ADSA leads to physical illness, mental illness, and suicidality (Schulte and Hser, 2013). On the positive coping strategy, Love et al. (2010) revealed wishful thinking and problem-solving attitudes, as some measures employed by construction workers.

2.6.1.9 Hypothesis for risk factors

Based on the preceding and the framework in Figure 2.2, this study hypothesizes that:

$H1_1$: Stressors (work or non-work) will relate positively to poor mental health symptoms (i.e., depression and anxiety).

$H1_{01}$: Stressors (work or non-work) will not relate positively to poor mental health symptoms (i.e., depression and anxiety).

Where: $H1_{01}$ = Null hypothesis for $H1_1$.

2.6.2 Protective factors

Rutter (1985) defined protective factors as those factors that modify, enhance, or alter a person's response to some environmental hazard that predisposes them to a maladaptive outcome. They function as a wedge against a risk factor or cluster of risk factors to reduce their impact (Mrazek and Haggerty, 1994, p.128). Protective factors are catalytic; like risk factors, they can reside in an individual, family, community, workplace, and social gathering. They can take the nature of either biological or psychosocial and influence one another. Protective factors include personal resources (e.g., resilience, self-efficacy, self-concept, hope); familial resources (family climate, family support); social resources (peer competence, social support) (see McDowell et al., 2019, Wille et al., 2008) and motivation (Werner and Smith, 1992).

2.6.2.1 Personal resilience[3]

Personal resilience is the capacity of an individual to cope successfully in the face of significant change, adversity, or risk (Stewart et al., 1997). Individuals can effectively deal with non-modifiable workplace stressors with resilience, strengthening mental health (Cooper and Cartwright, 1997). Resilience includes overcoming stress or adversity or resistance to environmental risk (Bowes and Jaffee, 2013). It is the ability to stand in the face of pressure (Hornor, 2017). It tells about the capacity for successful adaptation or regaining of health in the face of adversity, threat, or trauma. Under given conditions of risk or stress, the protective process that helps mitigate maladaptive outcomes is known as resilience (Greenberg, 2006).

Despite going through severe stress or risk exposure, some people can have good psychological outcomes. The ability or power to have such a good outcome is determined by resilience. Resilience is the factor that makes stress subjective (see Horn et al., 2016). Similar to children's studies, good physical and mental health is associated with high resilience in adults, while a high level of depression is prevalent among those with low resilience (Schure et al., 2013). A high level of resilience is related to positive wellbeing (de Paula Couto et al., 2011). Although resilience is a personality trait, it can be acquired via learning (i.e., acquired) over time (Cohn et al., 2009, Hornor, 2017, Wu et al., 2018).

Resilience is a coping resource; thus, it precedes the use of a coping strategy (Taylor and Stanton, 2007). This implies that the level of resilience determines what kind of coping strategy a person will employ. Avey et al. (2009) asserted that resilience is an essential positive resource to

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[3] This section is partially based on the article below produced by the author of the thesis during the PhD study: Nwaogu, J. M., Chan, A. P. C. and Tetteh, M. O. 2021. Staff resilience and coping behavior as protective factors for mental health among construction tradesmen. *Journal of Engineering, Design and Technology*. https://doi.org/10.1108/JEDT-11-2020-0464.

navigate a turbulent and stressful workplace. Resilience has been associated with coping skills; it influences high positive coping skills (Chen et al., 2017b). During adverse events, resilience influences how an individual appraised the stressor, whereas coping refers to the strategies employed after appraising the stressor (Thompson et al., 2018).

Resilience mediates and moderates the relationship between coping strategies and psychological outcomes (Wu et al., 2020, Tian et al., 2019, Smith et al., 2016) as represented in Figure 2.3. Evidence shows that high resilience predicts the use of social support and problem-focused coping (PFC) strategies for good mental health outcome, hampers the use of emotion-focused coping (EFC) strategies (Thompson et al., 2018, Rabenu and Yaniv, 2017, Wu et al., 2020, Gloria and Steinhardt, 2016, Li and Miller, 2017). Studies on resilience as a protective factor for mental ill-health seem scarce to date in the construction industry. Resilience can be measured using self-reported psychometric instruments such as the Brief Resilience Scale (BRS), Connor-Davidson Resilience Scale, and Ego Resiliency Scale (ERS).

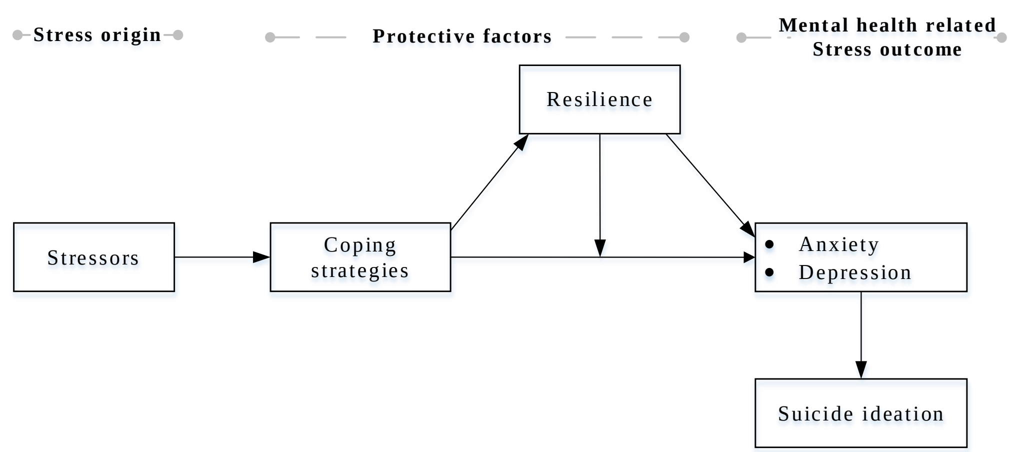

Figure 2. 3 The Stress-Coping-Resilience framework

2.6.2.2 Familial resources

Familial relationships such as living with family, satisfaction with family relationships, and family connectedness strongly impact mental health positively or negatively (Alegría et al., 2018). Specifically, good familial relationships have been associated with fewer depressive symptoms (Alegría et al., 2018), marital status of separated, divorced, or widowed are risk factors for depressions even among construction professionals (Kamardeen and Sunindijo, 2017).

2.6.2.3 Motivation

Motivation impacts employee's functioning and well-being (Fernet, 2013). However, there are two broad forms of motivation: autonomous and controlled motivation (Deci and Ryan, 2000). Controlled motivation is associated with negative burnout and turnover intention among the working population, while autonomous motivation is associated with psychological well-being (Fernet, 2013). Motivation has a moderating and mediating role in how employees adapt to the work environment, mental health, and job performance (Fernet, 2013). Therefore, putting resources within the workplace that initiates motivation would buffer the impact of excessive job demands (Bakker and Demerouti, 2017).

2.6.2.4 Social support

Social support is another positive (protective) factor to mental health and quality of life (Wu et al., 2018, So et al., 2013) and also plays a significant role in promoting resilience (Wu et.

2018; (Black et al., 2017). A high level of resilience has been found among married or co-habiting people (Guinnet et al., 2009) and amongst workers with greater colleague support (de Terte et al., 2014). Social support refers to support or assistance or protection offered to an individual by others (such as friends, family, colleagues) (Deming and Vasterling, 2017). It is a resource offered or exchange of resources between one or more persons (Cohen and Wills, 1985, Shumaker and Brownell, 1984). Social support is a significant coping resource (Taylor and Stanton, 2007).

Social support has four attributes: emotional, informational, instrumental, and appraisal support (Deming and Vasterling, 2017, Langford et al., 1997). Emotional social support has to do with care, trust, empathy, and love. It consists of supportive acts, affective assistance and is regarded as the best of all supports (Gottlieb, 1978, Norbeck et al., 1981). Instrumental support is tangible in nature and could take the form of financial assistance or assistance with job duties or roles (Langford et al., 1997). Informational support is given to a person when they are stressed or experiencing stress (Krause, 1986). Appraisal support is affirmational in nature, giving information related to self-evaluation (House, 1981, Kahn, 1980).

Social support outcomes are personal competence, behaviors for health maintenance (particularly coping behaviors), self-worth, decreased mental ill-health (anxiety and depression), and psychological well-being (Langford et al., 1997). Invariably, in an employee's context, social support could be work-based (work support) or non-work-based (non-work support). Work social support refers to support from within an organization context (Deming and Vasterling, 2017); it consists of supervisory support, providing problem-solving ideas, and encouraging effort (Gray-Stanley et al., 2010). Alternatively, support received from outside the workplace is known as non-work social support. Social support reduces the negative effect of occupational stress on physiological and psychological health (Pisarski et al., 1998). It helps alleviate physical and mental health problems by enabling pain reduction, stress coping ability, depression reduction, and improved quality of life (Wu et al., 2018).

Two social support models exist; one posits social support as a buffer to stress while the other posits it as having a direct effect. Model one is called the buffering model as it proposes that social support protects people from the ill effect of stressful events (Cohen and Wills, 1985). This model relates social support with well-being basically in persons going through stress or who have undergone stress. The second model proposes that irrespective of whether there is stress or not, social resources have a beneficial effect known as the main-effect (direct effect) model (Cohen and Wills, 1985). However, Nissly et al. (2005) opined that both models could not be treated as mutually exclusive as both functions simultaneously as they can be experienced at different times in an individual.

Amongst construction professionals, social support has been found to act as a moderator on stress (Haynes and Love, 2004). Going by the moderating effect of social support, it is found that social support can protect an individual under stress and maintain his or her good emotional experience (Wang et al., 2014). In the moderating model (see Figure 2.4), social support acts as a protective factor for health and wellbeing. In this model, such support moderates the negative influence that high levels of stress can cause and both independent of and antecedent to stress reaction and mental distress (Caesar, 2007, Lepore et al., 1991).

Several studies in the construction industry has shown that job support moderates the effect of job demand and low job control on health ((Bowen et al., 2013b, Bowen et al., 2014b, Bowen et al., 2014a, Cattell et al., 2016, Leung et al., 2014). Similarly, the studies revealed that an absence or shortage of work support was a source of stress and poor mental health. Thus, implying that low job support measures were risk factors for mental ill-health. Additionally, though studies into both work and non-work support and their influence on health in the construction industry are few, Love and Edwards (2005) found that non-work support was significant in alleviating stress effect than work-related support.

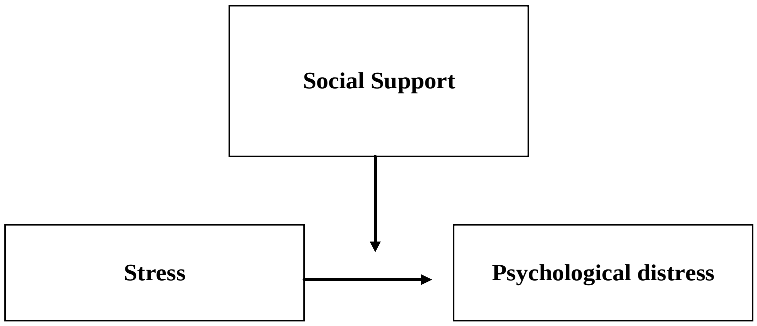

Figure 2. 4 Moderating effects of social support

Source: Lepore et al. (1991).

2.6.2.3 Coping strategy

A coping strategy or mechanism is a measure taken by an individual to respond to a stressful situation. It refers to a person's behavior and cognitive response to a stressful situation (Dolbier et al., 2007). Coping is a response exhibited by an individual and self-qualified as satisfactory or unsatisfactory to determine the demand in the required direction (Clarke, 1984). Clarke further noted that the effectiveness of coping mechanisms is highly person-specific and culture influenced. Moos et al. (1990) assert that coping is classified using two conceptual approaches. One approach is based on function (focus) as problem-focused and emotion-focused, and the other on coping methods as cognitive or behavioral. The coping strategy utilized would depend on the type of stressors (Moos et al., 1990).

Anderson (1976) opined that problem-focused coping behaviors are mostly employed when stress is at a moderate level, while at higher stress levels, emotion-focused coping behaviors are utilized. For stress, which is perceived to be low, the two types of coping strategies are employed with almost the same frequency. However, as the intensity of stress increases to moderate, problem-focused coping comes to play. Consequently, if the stress gets higher, emotion-focused coping will be used, and the circle between the coping types and stress levels continues. In stress management, when job stressors are perceived as a challenge, problem-focused coping behaviors are used, and when perceived as a threat, emotion-focused coping will be employed (Leung et al., 2006).

Lazarus and Folkman (1987) posited that coping performs two functions: problem-focused or emotion-focused, and that an individual can use both at the same time or interchangeably. Other authors described coping strategies as approach-oriented and avoidance coping (Moos et al., 1990). Problem-focused coping is an approach-oriented coping strategy involving an individual dealing with the situation by confronting the problem. Problem-focused coping (PFC) is behavioral, involving a person using a pragmatic approach to identify, define and solve stressors. On the other hand, emotion-focused coping takes avoidance, involving strategies used to push having to deal with a stressor. Emotion-focused coping (EFC) employs cognitive efforts such as denial or venting to mitigate the effect of a stressor. In avoidance coping, the individual aims at reducing emotional tension caused by such stressor (Soderstrom et al., 2000).

2.6.2.3.1 Types of coping strategies

Emotion-focused behaviors include accepting responsibility, avoidance, self-controlling, and distancing, while problem-focused behaviors consist of plan problem solving, positive reappraisal, seeking social support, and confrontive coping (Nwaogu et al., 2021). *Planful* *problem-solving* involves intentionally taking problem-focused and analytic approaches to solve the problem in order to alter the situation; *Seeking social support* includes employing skills related to seeking sympathy, informational and emotional support; *Positive reappraisal (problem reappraisal)* has a religious tone. The coping strategy focuses on personal growth and includes adopting skills that assist in creating a positive meaning (Folkman et al., 1986).

Confrontive coping strategy involves engaging aggressive or risk-taking efforts to eliminate the stressor in order to alter the situation. *Distancing coping strategy* involves making light of a stressful situation by detaching oneself from the situation to create a positive outlook; s*elf-controlling* involves employing efforts that help to regulate feelings and actions (Folkman et al., 1986). When adopting the *accepting responsibility coping strategy*, the person would acknowledge his or her role in the onset of the stressor, followed by efforts to make things right; *avoidance coping strategy* involves adopting escapist and wishful thinking skills so as to avoid the situation and its adverse effect (Folkman et al., 1986).

2.6.2.3.2 Coping strategies within the construction industry

There have been studies on coping strategies adopted by construction personnel; however, most employed weak methodologies. Bowen et al. (2014b), employing an exploratory study, found that South African construction professionals managed stress using a series of adaptive (problem-focused) and maladaptive (emotion-focused) coping strategies. Bowen et al. (2014b) found that the adaptive strategies adopted included exercise, recreational activities, and meditation, while maladaptive strategies were taking to alcohol and substance use. Roche et al. (2015) further asserted that male-dominated industries have a prevalence of alcohol use resulting from workplace psychosocial factors such as working conditions, occupational status, income level, and education. A study assessing coping strategies employed by Australian construction tradesmen using a validated coping construct scale (Brief Coping Inventory [BCI]) found that maladaptive coping, mainly substance use, was employed mainly by the category of workers (Langdon and Sawang, 2018).

Some other researchers opined that coping pattern differs according to gender differences as women frequently used avoidance (emotion-focused) strategies than men. However, there seems to be uncertainty on the trend in coping strategy with gender following inconsistency in research outcome (Ptacek et al., 1992). This difference in findings may be due to contextual and cultural factors. However, Carr and Umberson (2013) reported that men adopted problem-focused coping while women tended to employ social support and relied on emotion-focused coping strategies. Unlike the previous study, a study in the Construction Industry of Australia showed that gender is not a critical factor in coping strategy as both men and women employed problem-focused coping strategies (see Sunindijo and Kamardeen, 2017).

Sunindijo and Kamardeen (2017) also found that both genders employed the same emotion-focused coping strategies. However, women more than men coped with stress using social support and emotions venting while men turned to religion and spirituality more often. Thus, by comparing the results of the two Australian studies, it is deduced that coping strategies could be highly influenced by context and culture-specific to a workplace and/or country and, therefore, do not represent the situation in other countries. According to Bacharach et al. (2002), the connection between the work-related risk factors and problem drinking amongst male blue-collar worker seem complex. This may largely be influenced by the workplace culture, especially if permissive of drinking, thereby giving the workers room to employ emotion-focused coping instead of problem-focused coping in the face of stress (Bowen et al., 2014b).

Validated psychometric instruments used for assessing coping strategies within the construction industry include the Brief Coping Inventory (BCI) and Ways of Coping Questionnaire- WCQ (Folkman et al., 1986). However, the WCQ has been found to provide better results than the BCI. For example, Langdon and Sawang (2018) noted that the inconsistency of their result with previous studies might have been influenced by the BCI questions' inability to tap into some coping construct fully. The authors noted that the BCI acceptance coping responses read as *"accepting this happened"* and *"learning to live with it,"* which may have translated to a defeat to the respondents and resulted in flawed responses. The WCQ is also more comprehensive because it contains a sub-category for social support-related coping behaviors.

2.6.2.4 Hypothesis for the protective factors

Based on the preceding and the framework in Figure 2.3, this study hypothesizes that:

$H2_1$: PFC strategies will negatively relate to mental ill-health symptoms, while EFC strategies will positively relate to mental ill-health symptoms.

$H2_{01}$: PFC strategies will not negatively relate to mental ill-health symptoms, while EFC strategies will not positively relate to the mental ill-health symptoms.

$H2_2$: Resilience will negatively relate to mental ill-health symptoms.

$H2_{02}$: Resilience will not negatively relate to mental ill-health symptoms.

$H2_3$: Resilience will positively relate to PFC strategies and negatively relate to EFC strategies.

$H2_{03}$: Resilience will not positively relate to PFC strategies and negatively relate to EFC strategies.

$H2_4$: Resilience will mediate or moderate the effect of coping strategies on mental ill-health.

$H2_{04}$: Resilience will not mediate or moderate the effect of coping strategies on mental ill-health.

Where: $H2_{01}$ = Null hypothesis for $H2_1$; $H2_{02}$, $H2_{03}$ = Null hypothesis for $H2_2$, $H2_3$ respectively.

2.6.2.5 Measuring protective factors[4]

To date, protective factors researched in the construction industry are basically a reverse of risk factors with no strong methodological principles used to achieve them. In situations where protective factors only mirror risk factors, defective interventions are birth (Franklin et al., 2017, Nwaogu et al., 2019b). In order to arrive at effective interventions, studies into protective factors need to follow appropriate methodological distinction from risk factors (Wille et al., 2008, Nwaogu et al., 2019b). While there have been studies into stress-coping strategies in the construction industry, most of them neither linked coping strategies nor resilience to mental health among construction personnel.

Following the literature review, this study adapted the Brief Resilience Scale and Ways of Coping Questionnaire constructs to measure protective factors for mental health. Unlike other resilience scales, the Brief Resilience Scale (BRS) measures recovery in resilience. The scale shows great reliability and intraclass correlation coefficient (Rodríguez-Rey et al., 2016). It contains a six-point scale, scored by reverse coding with three positively and negatively worded items. Questions two, four, and six are reverse coded to indicate pessimism, while questions one, three, and five are positively coded, indicating positivism. The BRS employs a cut-off point

[4] Some aspects of this section is published in the article mentioned below:
Nwaogu, J. M., Chan, A. P. C., Hon, C. K. H. and Darko, A. 2019a. Review of global mental health research in the construction industry A science mapping approach *Engineering, Construction and Architectural Management* DOI 10.1108/ECAM-02-2019-0114.

ranging from 1.00 to 5.00, where 1.00 to 2.99 indicates low resilience. With the BRS, normal resilience ranges from 3.00 to 4.30, while 4.31 to 5.00 indicates high resilience (Smith et al., 2013).

The Ways of Coping Questionnaire (WCQ) is a 66-item checklist based on the stress and coping theory of Lazarus Folkman (1984). The WCQ is rated on a 4 point Likert scale and ideal for interviews or surveys (Folkman, 2013). The WCQ is the most widely used validated questionnaire to measure coping processes and applied in various occupations, cultures, and health concerns (Van Liew et al., 2016).

2.7 Evaluating the State of Mental Health[5]

Horwitz and Wakefield (2007) posit that depression is not sadness like people think. Horwitz and Wakefield's stance questions studies in the construction industry with affirmed conclusions on the prevalence of depression and anxiety amongst construction workers without measuring or assessing mental health. This emphasizes the importance of using a professional tool in screening for mental ill-health symptoms (Ali et al., 2016, Jeon and Kim, 2018). Jacobsen et al. (2013) revealed that rapid mental health assessment tools are essential, as nine in ten surveyed respondents on a construction site had mental ill-health challenges and had to be followed up medically. Of the stress-related researches in the construction industry, few studies have used validated scales (see Love et al., 2010).

Several validated mental health measurement screening scales screen for specific mental ill-health or general mental distress (King, 2018). They include Patient Health Questionnaire

[5] This section is largely published in the journal article below:
Chan, A. P. C., Nwaogu, J. M. and Naslund, J. A. 2020. Mental Ill-Health Risk Factors in the Construction Industry: Systematic Review. *Journal of Construction Engineering and Management,* 146**,** 04020004. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001771.

(PHQ), Generalized Anxiety Disorder (GAD), Depression, Anxiety and Stress Scale (DASS), and many more included in the review. A review of existing literature by Chan et al. (2020) found that sixteen (16) studies had been conducted into common mental ill-health symptoms in the construction industry. Out of the sixteen studies, eleven (11) mental health assessment tools were employed (see Figure 2.5). The tools were employed in 13 studies, while the three remaining studies probed mental health by using questions extracted from previous studies (see Table 2.2 above). Chan and colleagues found that the Depression Stress and Anxiety Scale was the most commonly used mental health assessment scale in the construction industry. Six of the assessment tools identified in the review and four (4) commonly used scales in the field of public health are discussed in this study.

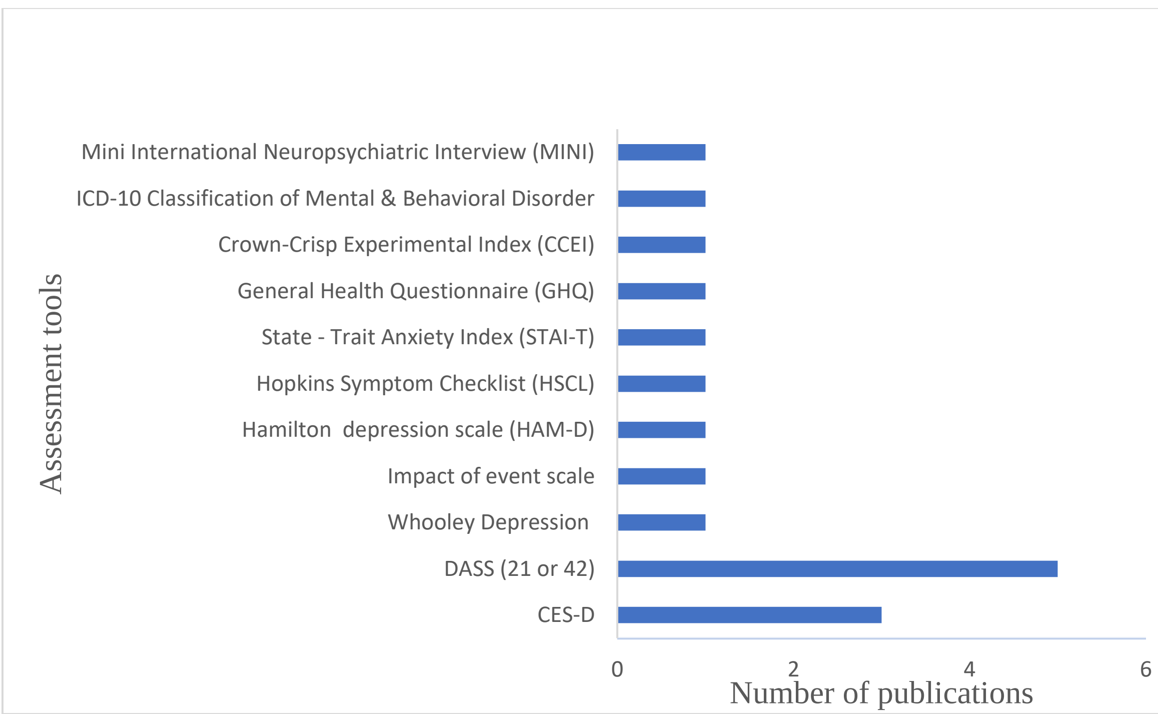

Figure 2. 5 Mental health assessment scales employed in the construction industry

Source: Chan et al. (2020).

2.7.1 Depression anxiety stress scale

The Depression Anxiety Stress Scale (DASS) is a freely available psychometric instrument available in variants of DASS 42, or DASS 21 used to determine the severity of depression, anxiety, and stress experienced over the past week (Ibrahim et al., 2014). Each variant has three subscales. The number in front of each variant signifies the total questions in the instrument. DASS42 contains 14 questions per subscale, while 21 contains seven questions each. DASS has shown excellent psychometric properties for evaluating mental ill-health among the working population and general populations (Nieuwenhuijsen et al., 2003). The DASS instrument effectively detects the change in mental ill-health conditions after a clinically diagnosed mental ill-health. In recent times, the DASS has been employed without a prior diagnosis (Ng et al., 2007).

2.7.2 General health questionnaire

General Health Questionnaire (GHQ) is a psychometric instrument available in variants GHQ-60, GHQ-30, GHQ-28, GHQ-12 with 60, 30, 28, and 12 item questions, respectively, used to assess somatic symptoms, anxiety, social dysfunction, depression, and emotional distress (Sterling, 2011, Okubo et al., 2011). The GHQ is copyrighted and evaluates psychiatric disorders and emotional distress based on preceding weeks.

2.7.3 Hopkins symptom checklist 25

Hopkins Symptom Checklist 25 (HSCL-25) is a psychometric instrument with 15 items on the depression subscale and ten items on its anxiety subscale, used to screen for anxiety and depression among traumatized and post-conflict populations (Halepota and Wasif, 2001). The review revealed the use of HSCL-25 to determine the state of mental health following pain and injuries in the construction industry (see Jacobsen et al., 2013).

2.7.4 CES-D (Center for Epidemiological Studies—Depression) scale

CES-D scale is a forerunner self-reported questionnaire available in variants of CES-D-10, CES-D containing 10, 20 questions, respectively, used to assess depression symptoms (Radloff, 1997). It can be used in the general population, research settings, or primary care facilities (Tomitaka et al., 2018). The questions are scored from 0 to 3. Similar to other psychometric instruments, a higher score indicates higher severity of depression. The questions in the CES-D are classified into two groups: those eliciting about depressive symptoms and those for positive affects (Tomitaka et al., 2018). On administering the CES-D, the presence of depression is indicated by a score greater than 16, while a score greater than 10 indicates depression in the CES-D-10 (Dyrbye et al., 2006).

2.7.5 Whooley depression

Whooley depression is a 2-item valuable questionnaire for identifying mental health problems but does not adequately indicate depression (Howard et al., 2018). The Whooley questions require a "yes or no" answer. If any respondent answers "yes" to any of the questions, another tool called the "help question" will be administered to him or her (Suija et al., 2012).

2.7.6 Mini international neuropsychiatric interview (MINI)

The MINI is used to diagnose depression, anxiety, and suicidal ideation (see Li et al., 2017). Although the MINI can be employed independently, it is often used as a second-stage mental ill-health assessment tool to gain more insight into certain concerns deduced in a prior assessment (Li et al., 2017). MINI allows for a "yes" or "no" answer. When the MINI or another psychometric instrument is administered, and a respondent is diagnosed with severe depression, the MINI module B is used for further examination. The MINI module B helps to assess suicidal ideation effectively.

2.7.7 Distress questionnaire (Kessler 6 or Kessler 10)

The distress questionnaire is a validated 6-item, or 10-item psychological distress severity assessment scale developed based on the item response theory used to assess the intensity of non-specific psychological symptoms (Batterham et al., 2018, Kaul et al., 2017). The K6 or K10 is used to measure the severity of psychological distress. K6 and K10 are a broad measure of psychological distress (i.e., depression, nervousness, restlessness, fatigue, worthlessness, and hopelessness) (Tomitaka et al., 2018).

2.7.8 Patient health questionnaire

The Patient Health Questionnaire is used for screening and diagnosing depression and available in variants of PHQ-9 or PHQ-2. The PHQ-2 assesses the frequency of depression using the first two questions of the PHQ-9, whereas the PHQ-9 assesses the severity of depression (Arroll et al., 2010). The PHQ-9 allows the understanding of suicide ideation using its ninth question (Tomitaka et al., 2018). The scale contains only nine questions which facilitates its use in busy settings. Chen et al. (2009) highlighted that the PHQ is fast and easy to use because it has only nine questions.

It evaluates the frequency of depression using a 4-point Likert scale. The scale ranges from 0 (not at all) to 3 (nearly every day), with a total score of 27. Cut-off points are used in the PHQ-9: 5 (PHQ-9 score 5-9) indicates mild depression, 10 (PHQ-9 score 10-14) indicates moderate depression, 15 (PHQ-9 score 15-19) indicates moderately severe depression, and 20 (PHQ-9 score 20-27) indicates severe depression). The PHQ-9 is one of the most widely used instruments for clinical depression screening, as it reflects the nine criteria for major depression in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (Chen et al., 2009).

2.7.9 Generalized anxiety disorder questionnaire

Generalized Anxiety Disorder is an efficient tool available in variants of GAD-7 and GAD-2 for screening and assessing GAD and its severity (Tong et al., 2016). The GAD-2 assesses clinically significant anxiety symptoms, whereas the GAD-7 assesses the severity of anxiety symptoms (Hughes et al., 2018). The GAD screens for anxiety using a 4-point Likert scale. The GAD-7 contains seven questions with each item describing one symptom of GAD (Tong et al., 2016), with the total score ranging from 0 to 21 and cut-off points 5 (mild), 10 (moderate), and 15 (severe). For the GAD-7, the recommended cut-off is nine, thus, score 10 and above are indicative of the likelihood of GAD (Tong et al., 2016). The GAD-2 contains the first two questions of the GAD-7, with total scores ranging from 0 to 6 and a cutoff of 3 for identifying anxiety symptoms that are clinically significant in the general population (Hughes et al., 2018).

The PHQ and GAD questionnaire screens for mental ill-health symptoms over two weeks are available in various languages and freely downloadable from https://www.phqscreeners.com. While Depression Anxiety Stress Scale (DASS) has been used in the construction industry, the PHQ and GAD are yet to be employed. In recent times, PHQ and GAD questionnaires are preferred by most researchers because it is fast to administer, the language is simple and easy to understand than the DASS (Adewuya et al., 2018). Thus, compared to other instruments, the PHQ and GAD questionnaires are adopted for digital mental health interventions.

2.7.10 Profile of Mood States (POMS)

The profile of mood states is a psychometric instrument used in the assessment of mood (Morfeld et al., 2007). It was initially available in 65 items with seven scales comprising depression, anxiety, fatigue, vigor, irritability, tension, and confusion (Morfeld et al., 2007). POMS has found considerable use in assessing the state of mental health in clinical psychology, sport science (Renger, 1993). It is also available in variants of short forms, including 35 items with four scales measuring depression/anxiety, fatigue, vigor, and irritability (Morfeld et al., 2007). The questions refer to mood experienced in the past week and the present-day within which the questionnaire is administered. The fatigue scale is particularly useful in sleep research (Shahid et al., 2012). Potential users of POMS can only purchase it after attaining a requisite course in psychometric measurement or evidence of appropriate expertise and training.

Following the literature review, this study adapted the PHQ-9 and GAD-2 for assessing the state of mental health among the personnel because the language of the PHQ and GAD questionnaires is simple, easy to understand, and they are fast to administer than other mental health assessment tools (Adewuya et al., 2018).

2.8 Work Stress and Physiological Health[6]

Stress refers to the adaptive behavior on mental responses of the body to everyday stressors (Hufnagel et al., 2017). Stressors could include performing a mentally or physically demanding

[6] This section is partially based on the article below produced by the author of the thesis during the PhD study: Nwaogu, J. M. and Chan, A. P. C. 2021b. Work-related stress, psychophysiological strain, and recovery among on-site construction personnel. *Automation in Construction,* 125**,** 103629. https://doi.org/10.1016/j.autcon.2021.103629.

task; they can be real, perceived, pleasant, and unpleasant (Hufnagel et al., 2017, Woda et al., 2016). This study adopts the view of stress as a negative response to daily stressors. In line with this, stress is defined as a negative impact (physiological or psychological) of a stressor. Among construction personnel, stress caused by daily stressors such as excessive job demands, long duty period includes physiological responses such as fatigue, sleep disturbances (Boschman et al., 2013, Powell et al., 2010), pain (Chung et al., 2019) while psychological response include depression and anxiety (Boschman et al., 2013, Frone et al., 1996).

Similar to previous studies (Boschman et al., 2013, Sadeghniiat-Haghighi and Yazdi, 2015), risk factors for work-related physiological or psychological stress include work quantity (workload), time pressure, and work speed (Järvelin-Pasanen et al., 2018). One such work-related stress response is fatigue and need for recovery, which indicates the wear and tear associated with work pressure (Rose et al., 2017). Boschman et al. (2013) reported that construction personnel, especially supervisors, suffered from a need for recovery than the general Dutch working population signaling increased mental ill-health risk caused by induced work fatigue. Notwithstanding how stressed a construction supervisor or tradesman gets due to daily stress, quality sleep is the only natural path through which recovery can be achieved (Powell and Copping, 2016).

The ability to sleep adequately for proper recovery is affected by excessive work pressures during the day, consequently increasing error rates, accidents, weakening the immune system, and reducing productivity (Basner et al., 2014, Alhola and Polo-Kantola, 2007). To understand the physiological health impact of occupational stress, studying autonomic arousal and recovery sleep is essential. During a stressful event, there is autonomic arousal causing an increase in sympathetic stimulation, thus decreasing heart rate variability (HRV) (Garza et al., 2015).

Although daily work offers access to the physical activity necessary to reduce ill-health risk factors, excessive stressful events during work can cause sympathetic overdrive of the autonomic nervous system (ANS), which may negatively affect sleep (Garza et al., 2015, Norton et al., 2010, Kubala et al., 2020). Therefore, maintaining higher HRV during the day can increase restorative sleep. To determine the impact of work stress on physiological health through recovery, previous works in the construction industry have employed both subjective and objective means (Bowen et al., 2018, Powell and Copping, 2010, Powell and Copping, 2016).

2.8.1 Wearable technology

Wearable technology has enhanced real-time physiological data collection among the working population without interfering with their duty (Guo et al., 2017). Wearable devices offer an easy-to-use, cheaper alternative to identify and reduce alarming workload in everyday usage (Schmalfuß et al., 2018). The wearable devices include those that employ cardiac activity, e.g., Photoplethysmography (PPG) equipped activity trackers and Electrocardiogram (ECG) equipped chest strap (Ahn et al., 2019). ECG device reveals cardiac activity through electrodes placed around the chest, which records electrical signals generated by the autonomic nervous system (Ahn et al., 2019). In contrast, PPG offers an indirect method to monitor cardiac activity by measuring blood flow volumetric change due to heart contraction phasing (Ahn et al., 2019). ECG sensor accurately measures HR and HRV because they directly measure electoral activity from the heart activity (Hwang et al., 2016, Schmalfuß et al., 2018). Additionally, in sleep medicine, wrist-worn activity trackers that use PPG have provided an alternative to standard clinical sleep quantification and classification techniques (Cook et al., 2019).

2.8.2 Physiological health indicators

Physiological indicators of work are useful in occupational health to enhance the prevention of long-term stress effects (Järvelin-Pasanen et al., 2018) as they provide rich information on user cognition (Gaskin et al., 2017). Important physiological indicators include cardiovascular measures (blood volume pulse, heart rate, HRV) (Gaskin et al., 2017, Léger et al., 2014, Mach et al., 2010).

2.8.2.1 Heart rate variability (HRV)

Work stress influences the autonomic nervous system (ANS) and affects cardiovascular measures, such as heart rate (HR) and HRV (Léger et al., 2014). During a cognitive effort due to stress, HR increases while HRV decreases. Unlike HR, HRV is an increasingly used biomarker of stress because it is a non-invasive means to assess the ANS control on the heart rate. HRV during the workday is also a predictor of sleep quality (Werner et al., 2015). Therefore, maintaining higher HRV during the day has been linked to better physical and mental health outcomes (Werner et al., 2015). McCraty and Shaffer (2015) define HRV as the "change in the time intervals between two heartbeats." HRV is determined using three parameters, namely time domain, frequency domain, and nonlinear parameters. The common measures for each of the parameters are outlined in Table 2.3.

Table 2. 3: Description of HRV parameters

HRV parameters	Units	Description
Time-domain parameters		The lower each time-domain measure, the lower the HRV
Mean R-R	bpm	- Mean of the selected beat to beat RR interval series - The lower the Mean R-R, the lower HRV
SDNN	ms	- The standard deviation of the interval between normal heartbeats - The lower the SDNN, the lower HRV
RMSSD	ms	- The square root of the mean squared differences of successive normal heartbeats
SDNNindex (SDNNI)	ms	- Mean of the standard deviations of all NN intervals for each 5-min segments of the total recording time
Frequency-domain parameters		
LF_{power}	ms^2	- Low-frequency power of the heart rate (range 0.04–0.15 Hz) - Estimates parasympathetic and sympathetic activation - The higher the LF_{power}, the lower HRV
LF_{power}	%	- Relative power of the low-frequency band (0.04–0.15 Hz) in percentage [i.e (LF_{power}/Total power) x 100%]
HF_{power}	ms^2	- High-frequency power of the heart rate (range 0.15-0.4Hz) in normal unit [i.e (HF_{power}/Total power) x 100%] - Estimates parasympathetic influence - The lower the HF_{power}, the lower HRV
HF_{power}	%	- The relative power of the high-frequency band (0.15–0.4 Hz) - Lower HF_{power} indicates stress, panic, anxiety, or worry
Stress Index (SI)		- It reflects a degree of heart rhythm management, and it is the square root of Baevsky's stress index in Baevsky and Berseneva (2008). - Where SI $\geq$ 30 is very high-stress intensity, High: 22.4–30; - Elevated 12.2-22.4; Normal 7.1-12.2; Low <7.1

Source: Järvelin-Pasanen et al. (2018) and Shaffer and Ginsberg (2017), Tarvainen et al. (2019).

Decreased values of each time-domain measure indicate a lower HRV (Garza et al., 2015), while an increased value of low-frequency (LF) power and decreased high-frequency (HF) power relates to a reduced value of HRV (Järvelin-Pasanen et al., 2018). Although the LF_{power} estimates parasympathetic and sympathetic activation, the sympathetic plays a significant role in generating the frequency (Järvelin-Pasanen et al., 2018). During rest, parasympathetic activation increases, causing an increase in HRV. Importantly, HRV provides insight into the parasympathetic nervous systems (PNS) and sympathetic nervous systems (SNS) and their interaction (von Rosenberg et al., 2017). As regards the sympathovagal balance (LF/HF), the reliability of employing a single metric has been criticized (Shaffer et al., 2014, Shaffer and Ginsberg, 2017, von Rosenberg et al., 2017), as a low LF/HF due to a low LF has a completely different meaning from a low LF/HF due to a high HF (von Rosenberg et al., 2017). Thus, to accurately interpret LF/HF, von Rosenberg et al. (2017) suggest considering the contribution of the LF and HF powers in HRV using a two-dimensional graph.

2.8.2.1.1 Validity of the HRV measures in measuring stress

The utility of wearable technology is influenced by individual (age, gender, average respiratory rate, body mass index), lifestyle (drinking, smoking, sleep, physical activity), and environmental factors (body position, noise, temperature) (Achten and Jeukendrup, 2003, Hwang and Lee, 2017). A decrease in HRV is related to elevated body weight, alcohol abuse, heat, and consumption of medications or harmful substances (Kim et al., 2018). Likewise, due to the physiological reaction that happens to the vegetative nervous system, climatic factors lead to changes in HRV (Kim et al., 2018). Thus, there is a need to evaluate the performance of measures used in commercial ECG and PPG based wearables in non-clinical populations.

Although breathing frequency affects metrics, evidence shows that time-domain HRV indices are less influenced by breathing than frequency domain measures (Francis et al., 2009, Speer et al., 2020). Overall, time-domain metrics have smaller variability and bias than frequency domain parameters, thus demonstrating good predictive ability (Kuss et al., 2008). In order to eliminate bias, the frequency domain's LF/HF ratio has to be interpreted with respect to HF power (Kuss et al., 2008). When documenting short-term (<10 min) HRV changes, frequency domain measures are found to be better tools (Francis et al., 2009). Additionally, to control for confounders, the percentage heart rate reserve (%HRR) has been used to understand how each worker physically responds to their unique job task (Hwang and Lee, 2017).

2.8.2.2 Percentage heart rate reserve (%HRR)

While individuals are subjected to varying levels of HR due to differences in internal body status (e.g., mental stress, hypertensive conditions), the heart rate reserve (HRR) focuses on the changes of HR that originate from physical workload (Hwang and Lee, 2017). Although mental factors have some effects on HR, the effect is negligible when HR is measured over a long time (Hwang and Lee, 2017). When investigating physical workload, conversion into HRR is significant (Hwang and Lee, 2017). HRR is an indicator of workload or pressure intensity related to muscular activities (Ismaila et al., 2013) and estimated, as shown in eqn. (2.1):

$$HRR = \left(\frac{HR_{working}-HR_{resting}}{HR_{maximum}-HR_{resting}}\right) \text{ x } 100\% \qquad (2.1)$$

Where: $HR_{working}$ = mean working heart rate; $HR_{resting}$ = resting heart rate; $HR_{maximum}$ = maximum heart rate (Ismaila et al., 2013, Hwang and Lee, 2017).

In the construction industry, HRR has been applied to categorize tradesmen into high and low physical demands as well as encourage work-rest schedules through continuous monitoring of physical demand (Hwang and Lee, 2017). Norton et al. (2010) suggested 40 to <60%HRR achieved through aerobic activity and sustained between 30-60minutes as a moderate level of physical demand needed for adequate health management among sedentary persons. However, the allowable workload limit for an 8-hour workday varied between the working population, including 30% HRR among teachers (Shimaoka et al., 1997), 24.5% among cyclists (Wu and Wang, 2002), and 30-40%HRR among construction tradesmen sustained for every 30-60mins (Hwang and Lee, 2017).

2.8.3 Sleep

Sleep is a key for well-being as it gives individuals the room to gain and replenish the resources needed to complete upcoming tasks (Kao et al., 2016, Medysky et al., 2017). Sleep is a necessary everyday activity and an essential determinant of health (Xiao et al., 2019). However, work-related stressors cause fatigue and pain, which eventually lead to sleep problems. Sleep problems and sleep deprivation are common in today's world. Sleep problems and deprivation are a serious threat to employees' health and well-being as both affect performance, increase fatigue, mental and physical ill-health. Inadequate sleep can limit the capacity to effectively manage stressors, thereby reducing resilience (Ogeil and Baker, 2015). Sleep with a duration fewer than seven hours (termed short sleep) and greater than or equal to nine hours (termed as long sleep durations) are risk factors for poor health and wellbeing, including mental disorders (Xiao et al., 2019).

Impaired sleep limits the cognitive resources and restorative sleep available to manage stress. In a high-stress work environment, it is crucial to mitigate incomplete recovery harms (Van Laethem et al., 2017). Likewise, insufficient sleep causes poor recovery in the construction industry and is an established predictor of occupational accidents and injuries (Chau et al., 2004, Kao et al., 2016, Philip and Åkerstedt, 2006). Sleep and stress have causal and reverse causal effects as high daytime stress negatively impacts restorative sleep. On the other hand, non-restorative sleep causes stress with detrimental effects (Van Laethem et al., 2017, Medic et al., 2017). The restorative effect of sleep is influenced by sleep quality and quantity (Doherty et al., 2019). Therefore, determining the leading causes of poor sleep quality and mitigating them is essential (Van Laethem et al., 2013). Two broad components used to examine the relationships between sleep, health, and well-being are sleep quantity and sleep quality (Pilcher et al., 1997). Although both components overlap, there exists a difference between them.

2.8.3.1 Sleep quantity

Sleep quantity (i.e., sleep duration) refers to the total amount of sleep obtained during the period of sleeping (Kline, 2013a), approximately 7 to 8 hours among adults (Hirshkowitz et al., 2015). However, this average number of hours does not indicate whether the actual sleep needed is met (Kline, 2013a). The common indices of sleep quantity are time in bed (TIB) and total sleep time (TST); they are used to determine sleep efficiency (SE). TIB is defined as total hours spent between getting into bed to sleep and eventually waking up (Kline, 2013a), while TST refers to the actual amount of time spent sleeping (Lee et al., 2018). Therefore, SE is expressed as a percentage ([TST/TIB]×100), where SE greater or equal to 85% (≥85%) indicates good sleep (Ohayon et al., 2017), showing no signs of insomnia (Reed and Sacco, 2016). A significant function of SE is the capturing of problems related to insomnia; thus, the ([TST/TIB]×100) formula of SE has been contested (see Reed and Sacco, 2016).

2.8.3.2 Sleep quality

Sleep quality refers to sleep parameters related to the sleep continuity variables (e.g., length of wakefulness during the entire sleep period, sleep efficiency) and sleep architecture (time spent in the different sleep stages, or arousals) (Kline, 2013b, Ohayon et al., 2017). Sleep quality is the parameter that indicates whether actual sleep need is met as it plays an essential role in the recovery mechanisms following work stress (Van Laethem et al., 2017) and predicts physical and mental health (Ohayon et al., 2017). However, it is better to consider the effect of sleep architecture variables together than individually (Ohayon et al., 2017). Ohayon et al. (2017) and Pilcher et al. (1997) further noted that using a composite measure for sleep architecture is more appropriate for sleep quality evaluation.

2.8.3.3 Sleep score

The sleep score reflects the sleep profile, communicating the recovery effect of sleep for good health (Lao et al., 2018). It gives information about the sleep quality by reflecting the collective impact of sleep architecture, sleep efficiency, and quantity (Lao et al., 2018, Landry et al., 2015). The sleep score provides a composite measure for sleep quality evaluation. Lower sleep score indicates lower restorative sleep and has detrimental physical health consequences, such as a higher risk of coronary heart disease (Lao et al., 2018, Dong et al., 2019). However, the sleep score provided by sleep tracking devices, including Fitbit Alta HR, ranges from 0 to 100 (see Table 2.4). With the rise in technology, wearable devices such as activity trackers are equipped for detecting sleep quality to report sleep scores, opening a new realm of objective sleep monitoring at a low cost (Lee et al., 2018). Following Ohayon et al. (2017), Malhotra and Avidan (2014), and Patel et al. (2018) four significant parameters of sleep architecture indicating sleep stages (i.e., rapid eye movement (REM), N1, N2, N3, and WASO) and sleep score are outlined in Table 2.4.

2.8.3.4 Sleep parameters

The non-REM (NREM) stage of sleep consists of N1, N2, and N3. While sleep efficiency is a measure of how well a person slept, it does not indicate or account for the frequency of wake times (number of awakenings while sleeping). Low TIB is a useful indicator in the diagnosis of insufficient sleep, as sleeping for 3 to 4 hours would affect the amount of sleep a person can get, the stages, and the cycle of sleep. WASO indicates sleep fragmentation, and it takes into consideration the number of awakenings and duration while sleeping. This implies that the period of awakening before sleep commences is not calculated in WASO. Complaints of non-restorative sleep may be caused by high levels of sleep fragmentation (Shrivastava et al., 2014). Additionally, a long period of wakefulness after sleep onset may be an indication of depression.

Light sleep (stage N1+N2) is also known as transitional sleep and accounts for about at least 5% of TST. It relates to the transition from the stage of wakefulness to sleep and a direct measure of daytime alertness (Shrivastava et al., 2014). Light sleep is that stage where a person is easily awakened, and where after waking, the person can deny having slept (Malhotra and Avidan, 2013). The quantity of sleep in stage N1 is an approximation of the degree of sleep fragmentation (N2) (Shrivastava et al., 2014). N2 is referred to as the intermediate sleep and accounts for about 50% of TST (Malhotra and Avidan, 2013), succeeds the N1, and continues to reoccur all through the sleep period (Shrivastava et al., 2014). Deep sleep (N3), also known as slow-wave, is the zone of refreshing and restorative sleep. The body repairs and strengthens its immune system at this stage (Patel and Araujo, 2018). During recovery sleep following sleep deprivation, a high amount of deep sleep is experienced (Shrivastava et al., 2014).

Deep sleep generally accounts for approximately 20% of TST. Deep sleep (N3) is vital and related to mental performance, as a person awoken while in this stage tends to have mental fogginess for approximately 30 minutes to an hour (Patel and Araujo, 2018). This is the stage when the body repairs and regrows its tissues, builds bone, muscle and strengthens the immune system. REM (stage R sleep) which is the stage at which dreams occur, accounts for approximately 25% of TST (Shrivastava et al., 2014), and it is termed paradoxical sleep or active sleep. Unlike the non-REM (NREM) sleep stages, during REM sleep, physiological activity is significantly higher (Malhotra and Avidan, 2013).

Table 2. 4: Description of sleep quality parameters

Sleep quality parameters	Description	Benchmark	Best fit range (%)
REM	This is the stage at which dreaming occurs, and it is critical in mood regulation, learning, and memory	≤ 25% TST	20-25
Non-REM Stage (NREM)			
NREM 1 (N1)	This stage promotes mental and physical recovery. It is a stage in sleep where a person is easily awakened.	≤ 5% TST	50-60
NREM 2 (N2)	This is the second non-REM stage, where eye movements stop, and the brain waves are slower.	≤ 50 TST	
Deep sleep (N3)	This stage promotes physical recovery, such as body repairs and strengthening of the immune system. It is a zone of refreshing and restorative sleep.	≤ 20 TST	16-20
WASO (wake after sleep onset)	This is the time spent awake during a night of sleep.	≤ 20 minutes	
Sleep score	It is a composite measure of sleep quality. It is an indicator of sleep quality.	Excellent Good Fair Poor	90-100 80-89 60-79 < 60

Source: Patel et al. (2018), Shrivastava et al. (2014), Fitbit Inc. (2020).

Notes: REM- Rapid Eye movement; NREM- Non-Rapid Eye Movement; WASO- Wake After Sleep Onset; TST- Total Sleep Time; NI+N2 – Light Sleep.

2.8.4 Hypothesis for the impact of work stress on physiological health

Based on the review of literature discussed, it is hypothesized that:

$H3_1$: Construction personnel with higher work pressure will have lower HRV.

$H3_{01}$: Construction personnel with higher work pressure will not have lower HRV.

$H3_2$: Parasympathetic variables (time-domain variables, HF) will positively relate to sleep scores.

$H3_{02}$: Parasympathetic variables (time-domain variables and HF) will not positively relate to sleep scores.

$H3_3$: Sympathetic variables (LF, LF/HF variables) will negatively relate to sleep scores.

$H3_{03}$: Sympathetic variables (LF, LF/HF variables) will not negatively relate to lower sleep scores.

Where: $H3_{01}$ = Null hypothesis for $H3_{1;}$ $H3_{02,}$ $H3_{03}$ = Null hypothesis for $H3_{2,}$ $H3_3$ respectively.

2.9 The Concept of Mental Health Intervention

The preceding sections discussed the risk factors for mental ill-health, protective factors for mental health, and how work stress could affect physiological health. To achieve this study's aim, solutions to stress, mental health, and well-being problems known as interventions are essential. The section covers job stress and mental health interventions adopted in several industries and construction.

Mental health intervention refers to health support guided by psychological methods and theory to improve human physical, mental, and social functioning and mostly delivered through a therapeutic process. Joyce et al. (2016) defined workplace interventions as any form of intervention which a workplace initiates or facilitates to prevent, treat, or rehabilitate an employee with mental ill-health symptoms such as depression, anxiety, or both. The need for interventions to reduce the impact of job stress is increasing because of the realized adverse effects of job stress on both individuals and organizations (LaMontagne et al., 2007). In preventive medicine terminology, interventions are either universal, selective, or indicated prevention, which parallels primary prevention, secondary, or tertiary intervention in public health terminology (LaMontagne et al., 2014). These interventions aim to reduce the onset of a health condition and mitigate the impact of associated risk factors (Joyce et al., 2016).

Primary interventions, also known as universal interventions, are proactive in nature and targets the job-context being the root cause of where the stressors emanate (LaMontagne et al., 2007). LaMontagne and colleagues noted that they aim to prevent exposure to stressors and the birth of illnesses among healthy employees or employers. They are referred to as stress prevention and mental ill-health risk reduction approaches as they are targeted at altering the physical or psychosocial work environment and changing toxic organizational culture. Examples of primary prevention interventions are job sculpting, job redesign, changing or altering the pace of work, enhancing social support, and implementing health and safety committees (LaMontagne et al., 2007).

Secondary interventions are stress response-focused and aimed at making better health outcomes through positive psychology techniques. Secondary interventions are targeted towards the individuals with the belief that the response of individuals to stressors is paramount in addition to or better than the elimination of stressors, which is the case of the primary intervention (LaMontagne et al., 2007). Secondary interventions are targeted towards specific risk factors or employees with particular risk factors, like those in high-risk occupations (e.g., construction, emergency services) to prevent mental ill-health, improve well-being by enhancing coping and resilience (Glozier and Brain and Mind Centre, 2017).

The progress of sub-clinical mental health problems can be prevented through secondary intervention (LaMontagne et al., 2014). According to LaMontagne and colleagues, secondary intervention examples include cognitive behavioral therapy, anger management, coping classes, and several stress management programs. These interventions are designed to equip individuals with appropriate know-how, skills, and resources to withstand stressful conditions (LaMontagne et al., 2007). Tertiary interventions are individual-centered and reactive in nature. They take place after a mental or physical ill-health has occurred following a stressor. Tertiary interventions can reduce mental health problems and related burdens through early detection and treatment, thereby limiting the severity (LaMontagne et al., 2014). They are both preventive and corrective and include Employee Assistance Programmes (EAPs), rehabilitation programs, and stress management programs (LaMontagne et al., 2007). Some programs can be classified differently; for instance, stress management can be secondary or tertiary intervention. Likewise, training on resilience building and adopting better coping strategies can be primary prevention if done before a mental ill-health occurrence.

Primary, secondary, and tertiary interventions are complementary and not mutually exclusive (LaMontagne et al., 2014). This implies that the interventions can be applied co-currently. According to LaMontagne et al. (2014), an integrated approach should be employed in a workplace mental health intervention. The integrated approach proposed includes (i) modifying or reducing risk factors to protect mental health; (ii) develop the positive aspect of the work, worker strength, and positive capacities; (iii) develop a system that addresses mental health problems among working people irrespective of the cause. There are a number of mental health interventions available, where a few construction industry context-specific interventions are introduced.

2.10 Mental Health Interventions in The Workplace

Workplace intervention for common mental ill-health ranges from prevention of depression, anxiety to suicide prevention and mental fitness promotion (Seaton et al., 2017). The psychosocial work environment is already an established risk factor for mental ill health (Tan et al., 2014).

2.10.1 Broader categories of workplace mental health interventions

A number of broader categories of mental health interventions which are single leveled/modal reviewed using systematic or meta-analysis and registered in the Cochrane database, are discussed in line with Glozier and Brain and Mind Centre (2017). The Cochrane database contains methodologically strong systematic and meta-analysis in the field of public health and occupational psychology. A review conducted and registered within the Cochrane database applies an internationally recognized grade system used by the World Health Organization (Theorell et al., 2015).

2.10.1.1 Flexible working arrangements/systems

Flexible working arrangements allow employees the opportunity to flexible work time and duration with no intention to reduce productivity or performance. Flexible work refers to work options that allow flexibility with respect to where the work is completed (Allen et al., 2013). It has been used for protecting against stressors such as work-family conflict and low job-control. It is important to note that risk factors do not act in isolation of each other but mostly occur in clusters (Chan et al., 2020). With respect to that, an emphasis on low job control is to signify the primary stressor. Low job control has been identified as a significant risk factor for mental ill health in the construction industry (see Boschman et al., 2013, Bowen et al., 2013a, Kamardeen and Sunindijo, 2017).

Certain interventions have been used to promote increased employee control, such as flexible working interventions (Joyce et al., 2010). Flexible working arrangements include self-scheduling, overtime, flexitime, overtime, gradual retirement, involuntary part-time, teleworking, and fixed-term contracts. The arrangements are categorized into three broad groups (see Figure 2.5). Flexible working systems, especially those that gave the employees a choice of decision about their timing (i.e., self-scheduling), yielded improved wellbeing.

Self-scheduling of work shifts was found to increase employees’ health, such as mental health, sleep quantity and quality, and blood pressure (Joyce et al., 2010). Similarly, compressed workweek arrangement has been reported to improve work-life balance in other industries and the construction industry (Lingard et al., 2007, Bambra et al., 2008). However, Lingard et al. (2007) did not use a validated scale to examine the impact of the intervention on the mental health of construction workers at the post-intervention stage.

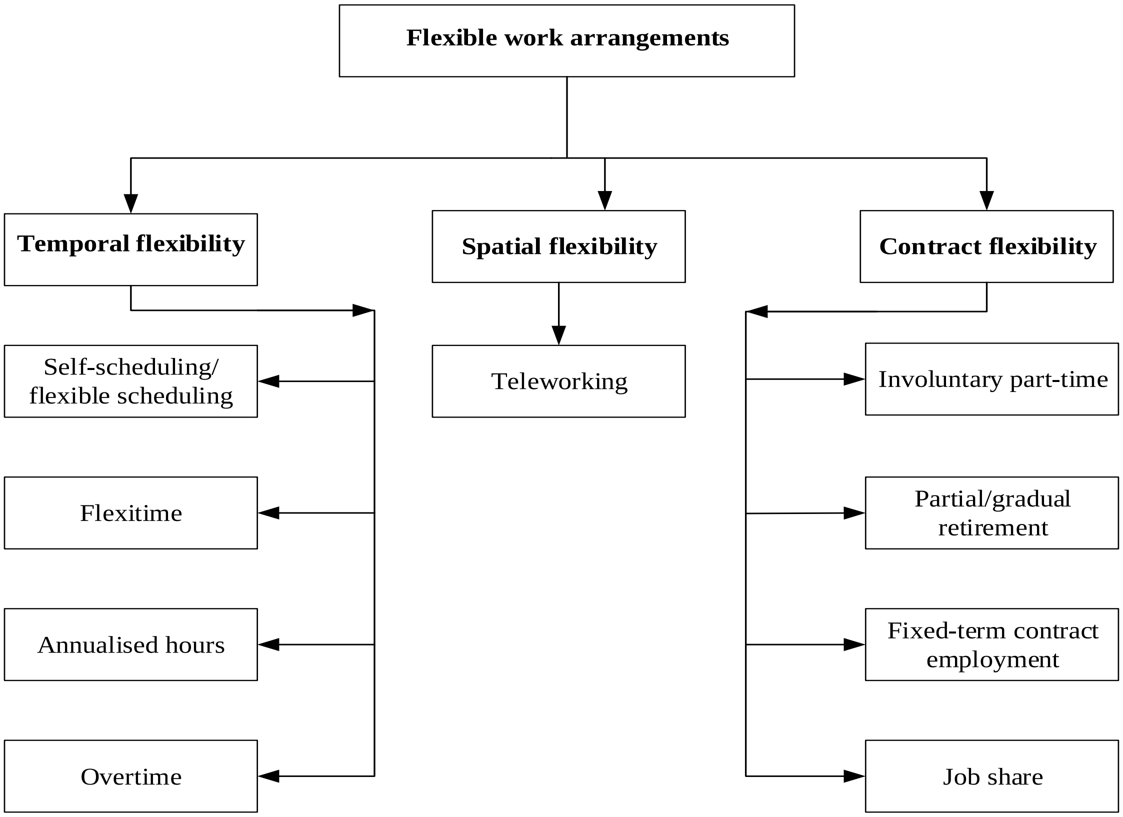

Figure 2. 6 Types of flexible work arrangements
Source: (Joyce et al. 2010).

2.10.1.2 Employee participation intervention

Participation interventions will help lower-grade employees improve their health through a psychosocial path; they increase job control, support, and mental and physical health (Egan et al., 2007). It is found on the premise that employees' participation in identifying a problem and suggesting potential solutions would increase their perception of job control (Mikkelsen and Saksvik, 1999). Mikkelsen and Saksvik (1999) noted that participation interventions are found on three theories, namely (i) participation, dialogue, and workplace democracy; (ii) occupational health; (iii) organizational learning theory. Strategies for employee participation interventions include problem-solving committees, education workshop, and stress management committee (Egan et al., 2007).

2.10.1.3 Manager and leadership training

The training of supervisors on mental health prevention has been shown by studies to impact on health, as supervisor's attitudes influenced the mental health of subordinates (Tsutsumi, 2011). The training intervention modules are designed to impart supervisors and managerial staff with knowledge about mental health policy and the best approach to tackle subordinates' mental health problems (Glozier and Brain and Mind Centre, 2017).

2.10.1.4 Mental health education program

These interventions are aimed at providing awareness on mental ill-health, reducing the attitudes of stigmatization and discrimination among employees. It includes mental health first aid (Glozier 2017). Mental health first aid is designed to combat mental ill-health and suicide. It is seen to improve supportive behaviors towards people in need to seek professional help. In the construction industry, mental health education programs have been adopted in Australia (see Gullestrup et al., 2011) and presently in the United Kingdom (Janusonyte et al., 2019). According to Glozier and Brain and Mind Centre (2017), "there is minimal evidence on the effectiveness of mental health education programs such as MHFA." Reported evidence of MHFA includes improvement of attitudes and help-seeking behaviors, with a significant effect on knowledge improvement (Glozier and Brain and Mind Centre, 2017). However, there is no significant effect of MHFA on mental health improvement; instead, it helps improve mental health and suicide beliefs in the Australian construction industry (King et al., 2018).

2.10.1.5 Anti-bullying programs

Bullying in the workplace is a top stressor to health, causing job dissatisfaction, higher levels of mental ill-health, and employee turnover intentions (Gillen et al., 2017). Though often misinterpreted for harassment, bullying is not the same (McMahon, 2000), and both arise due to workplace culture. The culture present in a workplace influences the attitude of employees toward each other. Thus, attitudes of bullying and harassment need to be prevented to promote healthy workplace culture (Gillen, 2007, Gillen et al., 2017). The anti-bullying intervention is a culture change intervention and is particularly a primary prevention intervention. An example of anti-bullying intervention is the Crew, Respect, and Engagement in the Workplace (CREW). Most studies on such intervention have reported a reduction in supervisor incivility but no significant decrease in co-worker incivility (Glozier and Brain and Mind Centre, 2017).

2.10.1.6 Employee assistance program

Employee Assistance Program (EAP) has been reported to have a significant positive effect on mental health but depends on the participation of highly trained clinical psychologists. EAP interventions are designed to help employees cope better with work and non-work factors such as mental distress, lifestyle issues, marital and financial issues, and a host of personal and family challenges (Soeker et al., 2016). The EAPs are designed to address all types of problems that affect employees' well-being and performance negatively (Burke, 2014). The winning edge of the EAP is that it focuses on a variety of issues which an employee face within and outside the workplace, including substance abuse and dependency, mental and personal relationship problem.

Most organizations in industrialized countries use EAP interventions as a response to job stress and its adverse effects (LaMontagne et al., 2014). Workplaces that offer assistance on non-work stressors are seen as better supportive, thereby promoting a healthier perception of the workplace, better health, and performance (Burke, 2014). EAPs though old, are currently advocated for as they are rebranded to be broad in scope to cover all non-work factors that influence an employee's mental and physical health and performance. This is so considering the National Institute of Mental health statistics that 66% of all terminations and 30% of all absenteeism in a workplace arises from personal problems and not work-related problems (Carchietta, 2015).

2.10.1.7 Resilience training

Enhancing resilience is essential, as the level of a person's resilience determines the possibility of future mental ill-health. In recent times, the benefits of resilience are leveraged upon, as such resilience-based interventions are promoted. There is evidence of the possibility to teach and acquire resilience by incorporating both CBT and mindfulness techniques with a resultant reduction in stress, burnout, and improved mental health (Luxton et al., 2014, Luken and Sammons, 2016, Sood et al., 2014).

2.10.1.8 Physical activity interventions

The impact of physical activity on employees' mental health has been examined with the promises of reduced anxiety and absenteeism through exercises and relaxation techniques (Rebar and Taylor, 2017, Bhui et al., 2012). Physical activity is related to several health benefits, leading to the inclusion of regular exercise in primary prevention, treatment, chronic diseases, and premature mortality (Josefsson et al., 2014). Exercise is believed to be effective in depression prevention and reduction in clinical and non-clinical populations (Josefsson et al., 2014). Physical activity interventions are particularly advocated as a component of workplace health promotion. However, Joyce et al. (2016) argued that there is concern about the intensity and amount of physical activity which would improve wellbeing.

With the increased use of wearable technologies, ensuring physical interventions and their impact on wellbeing has improved (Lee et al., 2018). The wearables (i.e., fitness or activity trackers) also enhance physical activity auditing and dedication with features such as goal setting, reminders, and social influence. The adoption of wearables in the construction industry is increasing, primarily geared towards safety management and not related to physical and mental health self-management.

2.10.2 Interventions strategies for mental health in the workplace[7]

According to Tan et al. (2014), "workplace interventions can be multi-modal in simultaneously reducing known risk factors while enhancing individual coping skills and resilience." The questions that arise are: (i) why are emphases made on only single-mode interventions, e.g., the broad classifications in the previous section? (ii) why are emphases made on workplace interventions when the sources of stressors of mental and physical ill-health are not only psychosocial work-based? The cause of mental ill-health and other health outcomes are not only based on the workplace psychosocial factors. For instance, LaMontagne et al. (2014) opined that an integrated mental health framework must address mental health problems among working people irrespective of the cause. Researchers have also emphasized the importance of considering the impact of non-work related, individual-level factors and health behaviors in addition to work factors when researching into mental health (Bartley, 2004, Joyce et al., 2010). The workplace has been identified as an avenue or medium for carrying out mental health interventions because the workforce spends about half of their productive daily time in it (Mykletun and Harvey, 2012).

Several primary, secondary, and tertiary intervention strategies have been adopted from the broad classifications to support mental health at individual or organizational levels following employees' needs (see Table 2.3). Studies on strategies to improve mental health focused on job stress mitigation (e.g., Havermans et al., 2018, Pignata et al., 2017, Pignata et al., 2018) and mental ill-health symptoms (e.g., Joyce et al., 2010, Joyce et al., 2016, Tan et al., 2014, Gullestrup et al., 2011). Pignata et al. (2017), examining employees in the education sector, deduced that academic

[7] Nwaogu, J. M., Chan, A. P. C. and Tetteh, M. O. 2021. Staff resilience and coping behavior as protective factors for mental health among construction tradesmen. *Journal of Engineering, Design and Technology*. https://doi.org/10.1108/JEDT-11-2020-0464.

staff employed mostly secondary interventions such as coping strategies to reduce stress. In contrast, non-academic staff relied on organization-level strategies to reduce and manage stress among employees. Pignata et al. (2018) found that strategies put in place to reduce stress in five Australian Universities include: remuneration raise, improving recognition practices, practice fairness, career development, and measures to improve work-life balance. The findings in Pignata et al. (2017) and Pignata et al. (2018) emphasize that a single-modal intervention strategy (i.e., secondary, primary, or tertiary) is not adequate for stress mitigation and mental health management.

Havermans et al. (2018) reported that communication about stress, supportive workplace, availability of stress prevention measures were some strategies perceived by employees to reduce stress. Generally, a meta-analysis by Tan et al. (2014) showed that most organizations employed secondary intervention to mitigate mental health problems among workers. However, while they assist in coping and resilience building, secondary interventions are ineffective in modifying risk factors and, as their effect wears out in a short time (Joyce et al., 2016, LaMontagne et al., 2014). Thus, reinforcing the need for implementing multi-modal intervention strategies in the workplace. A few single-modal intervention studies within the construction industry (either secondary or primary intervention strategies) considered mitigating mental health problems. For instance, Gullestrup et al. (2011) adopted multimodal secondary and tertiary intervention strategies such as mental health literacy, stimulating helping behaviors, and some aspects of employee assistance program to mitigate suicide among construction tradesmen in Australia. However, while the multimodal intervention increased mental health literacy, it showed no effect on enhancing coping or reducing mental ill-health and suicide.

Additionally, primary intervention strategies such as job redesign strategies have been evaluated in the construction industry (see Yip and Rowlinson, 2009, Lingard et al., 2007). Using a compressed working week strategy, Lingard et al. (2007) achieved increased work-life balance and productivity. Yip and Rowlinson (2009) reported mild effectiveness against burnout sources (emotional exhaustion, cynicism, and professional efficacy) using a reduced workweek and a scheduled fortnight Saturday off-work strategy. However, both studies did not provide for non-work factors that can cause or worsen mental ill-health to which the primary intervention will be ineffective.

Table 2. 5: The potential mix of strategies to improve mental health in the construction industry

Code	Strategies to improve mental health
ST01	Empower staff to be individually more resilient through resilience training programs
ST02	Introduce wellness programs to workplaces/site offices
ST03	Promote talks about anti-stigma (anti-stigma campaign)
ST04	Promote mental health awareness through literacy programs
ST05	Stimulate helping behaviors towards people suffering from mental health problems through mental health first aid
ST06	Put measures in place for exercises such as exercise weekends
ST07	Provide practical stress management training
ST08	Create policies to eliminate bullying
ST09	Create policies to eliminate harassment
ST10	Promote equality policies irrespective of gender, and age
ST11	Promote employees' deeply embedded life interest
ST12	Employees should be allowed some flexibility to design their job roles and tasks while human resources approve it inline with the job position and goals of the organization
ST13	The workplace should allow site employees' a flexible work schedule with regards to work time and duration with no intention to reduce productivity or performance
ST14	Put better education policies in place (e.g., providing subsidies for / encouraging employee career development
ST15	Reduce threatening of staff with disengagement when they make mistakes
ST16	Give constructive feedback instead of reprimanding
ST17	Ensure swift conflict resolution
ST18	Celebrate employee's success
ST19	Offer employee's opportunities to balance work and life using compressed working week arrangements
ST20	Allow the taking of regular breaks to enable rest
ST21	Better planning of work tasks and shifts
ST22	Hire more personnel to reduce the workload
ST23	Conduct employee satisfaction surveys
ST24	Conduct regular team meetings with supervisors and subordinates focused on addressing work stress
ST25	Promote communication about work stress from supervisors or subordinates without penalty
ST26	Provide employees with competence training
ST27	Supporting improved relationships at work
ST28	Put in place measures that increase cooperation between colleagues
ST29	Offer assistance to non-work stressors such as marital challenges
ST30	Provide aid for stressors such as financial challenges
ST31	Offer a sustainable retirement plan for employees

(Adapted from Bakker and Demerouti, 2017, Burke, 2019, Enns et al., 2016, Gullestrup et al., 2011, LaMontagne et al., 2014, Pignata et al., 2017, Pignata et al., 2018, Tan et al., 2014).

Therefore, as previously established, to ensure a sustainable mental health promotion in the industry, adopting an integrated approach to mental health management is most reliable because it offers opportunities to modify and mitigate risk factors irrespective of their source. Based on the integrated approach, a mix of 31 intervention strategies that could be implemented to help provide a construction workplace that promotes psychological health and safety were adapted from existing literature.

2.11 Hypothesis for the Impact of the Intervention Strategies

Based on the review of literature in Section 2.6 and Section 2.10, it is hypothesized that:

$H4_1$: The integrated strategies will be negatively associated with the stressors or risk factors.

$H4_{01}$: The integrated strategies will not be negatively associated with the stressors or risk factors.

$H4_2$: The integrated strategies will be negatively associated with mental ill-health symptoms.

$H4_{02}$: The integrated strategies will not be negatively associated with mental ill-health symptoms.

$H4_3$: The protective factors will be negatively associated with the mental ill-health symptoms.

$H4_{03}$: The protective factors will not be negatively associated with the mental ill-health symptoms.

Where: $H4_{01}$ = Null hypothesis for $H4_{1;}$ $H4_{02,}$ $H4_{03}$ = Null hypothesis for $H4_{2,}$ $H4_3$ respectively.

2.12 The Research Gap

From the literature on risk and protective factors in the construction industry, some limitations were evident. First, many published works on risk factors for mental ill-health in the construction industry focused on identifying psychosocial workplace stressors and recommending intervention strategies. Only a few such studies (Kamardeen and Sunindijo 2017; Langdon and Sawang, 2018) considered non-work factors, and both were conducted in the Australian construction industry. Likewise, studies on protective factors focused mainly on coping strategies construct and social support construct. To date, no previous study in the construction industry has examined resilience as a protective factor for mental health. There are varying contextual and cultural influences on factors influencing mental health, just as construction and safety practices vary between countries. This raises important implications as stressors identified as significant by previous studies may not wholly apply to construction supervisors and tradesmen in Nigeria.

Additionally, the intensity of their influence may vary, making it essential to determine risk factors and protective factors for mental health and adjustments necessary to develop interventions for mental health in the study area. Additionally, this research differs from previous studies by employing objective measures to collect data on sleep quantity and quality following daily work stress as means to evaluate the impact of work pressure on physiological health. As stressors act in clusters to influence health, objectively collecting heart rate variability during a day's task followed by objectively collected data on sleep the same day might give information that will assist in building sustainable interventions on mental health and well-being.

2.12 Chapter Summary

Stress in the workplace and outside affects both physical and mental health, while both have a reverse causal effect on each other. For instance, Naoum et al. (2018) found that a poor home environment caused burnout. The chapter highlighted how socio-demographic features could negatively affect mental health. It also highlighted certain individual-protective factors and job resources (i.e., workplace intervention strategies) that can help protect a person from developing mental ill-health and maintain good mental health. The chapter concluded by identifying intervention strategies that have form the basis for randomized intervention studies for mental ill-health prevention among working populations. The succeeding chapter discuss the theoretical framework and conceptual model for the research.

CHAPTER 3: THEORETICAL AND CONCEPTUAL FRAMEWORK

3.1 Preamble

In this chapter, the theory underpinning the study is discussed to elucidate construction personnel's interactions to stress and attempts to adapt. The research problems and aim informed the choice of theory. The theory adapted for the study is the Job Demand-Resources (JD-R) theory.

3.2 Job Demand-Resources (JD-R) Theory

A review by Järvelin-Pasanen et al. (2018) noted that the two most used occupational stress models and theories are Karasek’s Job-Demand-Control (JDC) and Siegriest’s Effort-Reward Imbalance (ERI) theory. In the construction industry, the commonly used theories in relation to job-related stress among the working population are JDC and JD-R theory (Bakker and Demerouti, 2017). The JD-R model and theory build on prior occupational stress outcome models such as the Effort-Reward imbalance models (ERI) (Siegrist and Peter, 1994), Job-demand-control model (Karasek Jr, 1979), and stress models (Selye, 1976).

The JD-R has flexibility over prior models; thus, it can be adopted among varying occupational groups, which is an additional reason it is adopted for this study. For instance, in the ERI, work pressure or (intrinsic and extrinsic) effort are the most critical job demands. Simultaneously, salary, esteem, reward, and status control were essential job resources that compensate for job demands (Bakker and Demerouti, 2007). Job autonomy was not incorporated in the ERI model, which is a drawback since specific job demands such as emotional demands and mental demands are prevalent in occupations such as teaching, medical, and construction (Bakker and Demerouti, 2007).

The JDC model focused on role conflict, work overload, and time pressure as measures of job demands, with assertions that the fear of unemployment or career problems can contribute to the measures, with skill discretion and decision latitude as job control measures (Bakker and Demerouti, 2007). The JD-R carters for the shortcomings of prior models, such as the limited set of variables that may not apply to all job positions, allow for the integration of other work-related factors related to well-being (Bakker and Demerouti, 2007). This implies that the model adopted can be tailored to meet a specific need or situation and different occupational groups (Schaufeli and Taris, 2014).

According to Bakker and Demerouti (2017), job demand refers to "the physical, mental and social aspects of the job that requires sustained physical and/or mental effort and associated with psychological or physiological costs." Bakker and Demerouti (2017) defined job resources as "the physical, mental, social aspect of the job that are functional in achieving work goals, reduce job demands and its associated physiological and mental costs, as well as stimulate personal growth, learning, and development." Examples of job demands include high work pressure, physical work demands, emotional work demands, and work-home conflict. Some examples of job resources include job autonomy, good supervisor-subordinate (interpersonal) relationships, feedback on performance, social support, skill variety, and growth opportunities (Bakker and Demerouti, 2017).

The JD-R model is concerned with personal characteristics and strategies within the work environment that can mitigate job demand and help fulfill goals (see Figure 3.1). The model has six propositions, including job resources (i) buffers the effect of job demand, (ii) influences motivation, especially when the job demand is high, while motivation impacts positively on performance. The model further asserts that personal resources can provide the same level of influence on job demand as job resources. The question is, how does the theory impact good mental health and physiological health? Under stressful conditions, employees are more likely to use some job resources and personal resources to respond to the situation effectively. The JD-R theory impact mental and physiological health, which is the focus of this study, as it proposes that employees may be more at risk for burnout or other stress outcomes when confronted with high job demands and low job resources if their personal resources are low (Demerouti and Bakker, 2011). Such employee stress outcome includes burnout, distress, depressed mood, anxiety, and psychosomatic symptoms (Schaufeli, 2001).

Additionally, the theory postulates that employees are likely to be engaged in their work and perform better in the case of active jobs (i.e., high job demands and job resources are high) when their personal resources (such as resilience and hope) are high (Demerouti and Bakker, 2011). In adapting the model, the personal resources are itemized as resilience to align the outcome with positive psychology theory. Personal resources refer to the psychological capital of resilience, self-efficacy, hope, or optimism. Personal resources relate positively to well-being, employee performance (Avey et al., 2011, Siu, 2013, Rabenu et al., 2017) and negatively to stress, burnout, anxiety, depression, and negative affect (Avey et al., 2011). In understanding the stress epidemic and managing it, an insight into psychological capital is essential (Avey et al., 2009). Flexibility in using coping mechanisms and selecting the most appropriate coping strategy to meet low job resources is necessary (Bakker and Demerouti, 2017, Westman, 2004), but it depends on the pool of resources available to employees (Lazarus and Folkman, 1984).

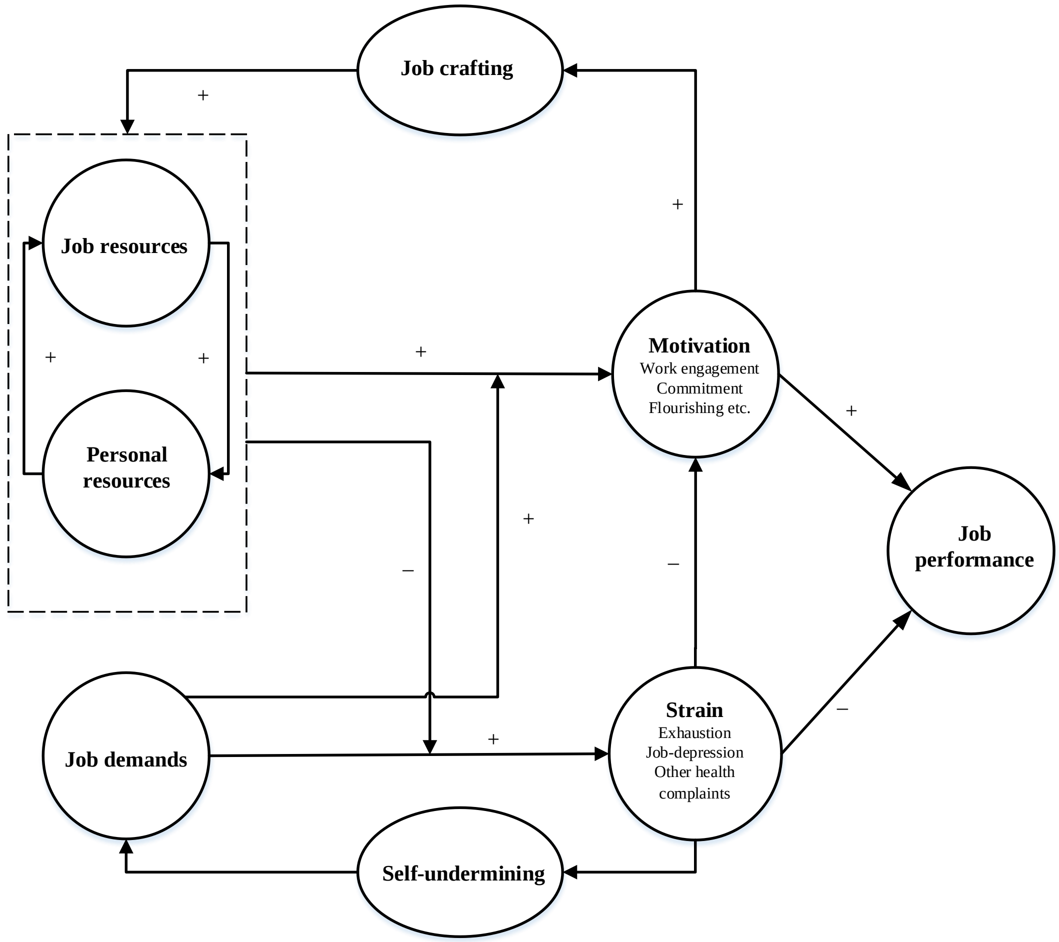

Figure 3. 1 The job demand-resources model
(Adopted from Bakker and Demerouti, 2017)

In order to deal effectively with stress and its mental health-related outcomes, the adoption of well-suited and effective coping outcome responses is also essential as they hold the possibility of ensuring positive outcomes such as physical and mental health. Ntoumanis et al. (2009) noted that the consequences of coping strategies employed in situations differ and never consistent because of the difference in what motivates a person. As pointed out in the JD-R model, the concern of motivation is also essential to cognitive appraisals and coping responses. Although direct relationships have been found between motivational regulations, coping, and mental needs, the relationship may be mediated by stress appraisal (Ntoumanis et al., 2009). In which case, motivation can be formed through stress appraisal and the desired outcome. For instance, if flourishing (i.e., complete mental health) as indicated in the JD-R model (see Figure 3.1) is intended, the motivation to apply certain coping strategies is formed.

3.3 Synthesis of the Theoretical Framework and Conceptual Framework

The JD-R guides the formulation of the survey questions. The risk factors for mental ill-health relate to the job demand and self-undermining factors (such as the non-work stressors and work stressors). In contrast, the protective factors comprise personal resources and coping behaviors. The theory is designed to aid the understanding of (i) daily work and non-work stressors on mental and physiological health outcomes; (ii) the role of psychological capital (i.e., resilience) and coping strategies; (iii) job resources; (iv) job redesign, particularly job crafting in ensuring a psychologically healthy and productive employee, and safe workplace.

Based on the literature review and theory, a conceptual framework for the study is developed (see Figure 3.3). It is conceptualized that in adapting the JD-R theory, (i) job resources should be replaced with the intervention strategies; (ii) job sculpting should be introduced to job crafting, and both should form part of the intervention strategies; (iii) the intervention strategies will improve coping strategies and resilience level as well as mitigate risk factors and poor mental health symptoms; (iv) sleep intervention will improve physiological health. Taylor and Stanton (2007) pointed out that coping resources such as resilience, optimism, self-esteem, and social support are antecedents to coping strategies that directly affect mental and physical health.

Job sculpting refers to the process of redesigning a job in line with the personal interest or deeply embedded life interest of a person. Job sculpting is a process that matches an employee to a job responsibility that allows the employee to express his or her deeply embedded life interest

(Butler and Waldroop, 1999, Ganesan and Gauri, 2012). Deeply embedded life interest drives the kind of activities that make people happy (Butler and Waldroop, 1999). In job sculpting, the manager is the designer but designs the job based on each employee's embedded life interest. On the other hand, job crafting involves the employee as the designer, as he crafts the tasks in a way to have some control over them and create some positive image (Kroth and Kroth, 2007).

According to Wrzesniewski and Dutton (2001), job crafting is “the physical and cognitive changes individuals make in the task or relational boundaries of their work.” Job craft is an individual-level activity that involves the employee deciding how and when to shape his or her job task and interaction (Wrzesniewski and Dutton, 2001). Examples of job crafting include an employee changing the number and type of job tasks or crafting social encounters with colleagues (Leka and Sinclair, 2014). Job sculpting and job crafting mirror one another (Kroth and Kroth, 2007). To make work and the workplace more motivating, perceived as less stressful, and increase well-being and performance, it is vital to allow employees to craft their job and managers sculpt the job after them (Kroth and Kroth, 2007). Adopting job sculpting in line with job crafting could ease the work for both parties. Since job crafting is good for the individual but might have a positive and negative effect on the organization (Wrzesniewski and Dutton, 2001), job sculpting would help eliminate any adverse impact on the organization.

Following the JD-R theory, to achieve the aim of the study, hypotheses in Section 2.6.1.9, Section 2.6.2.4, Section 2.8.4, and Section 2.11 were harnessed to arrive at a conceptual framework for the study (see Figure 3.2).

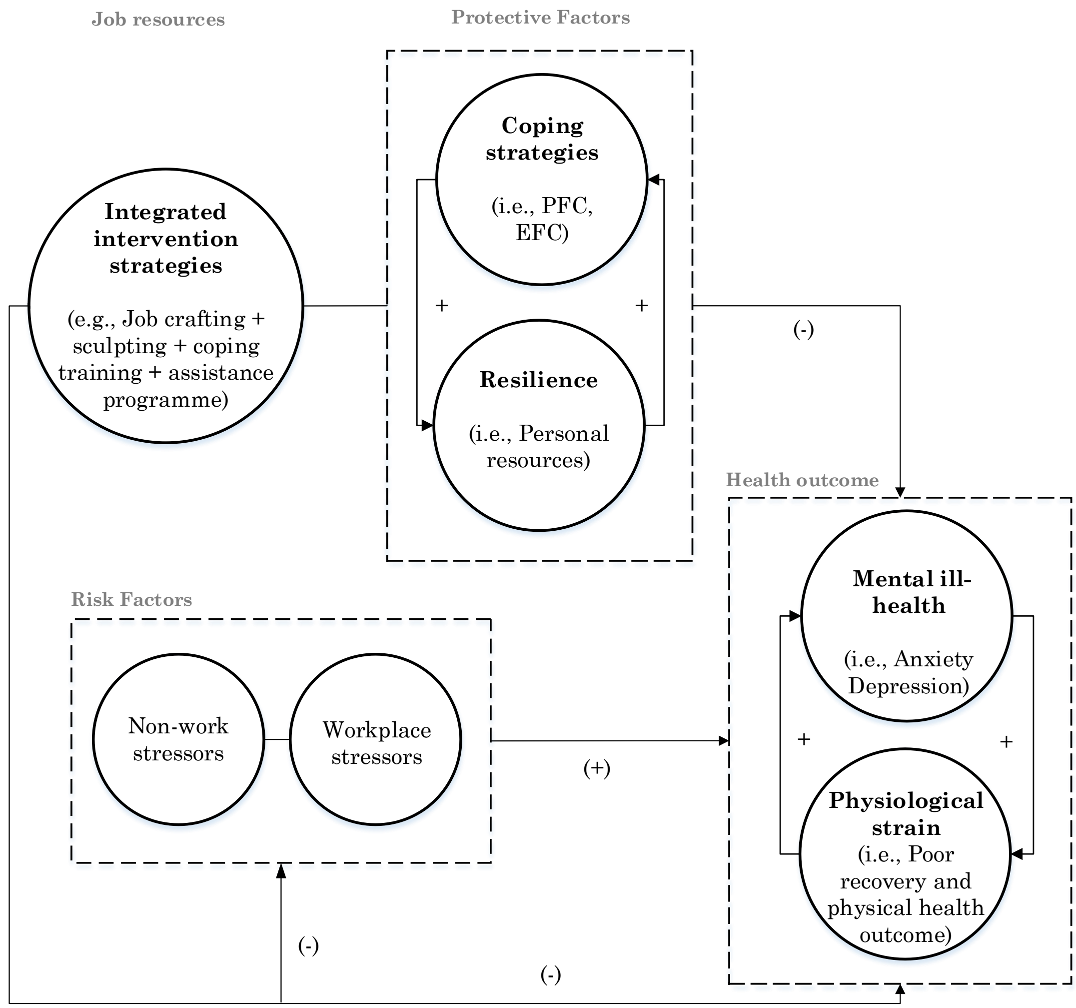

Figure 3. 2 Conceptual framework for the study

3.4 Chapter Summary

This chapter discussed the theory that underpins the study and the conceptual model for the study. One author, LaMontagne et al. (2014) stated that studies related to intervention building need to be guided by theory or sound principles. Since this study considered the effect of both work and non-work stressors on mental health and well-being of construction personnel, concepts explained in the previous chapter and theories explained in the present chapter were used to guide the formation of a conceptual framework. The chapter outlined the theories that guide the need assessment required to determine what combination of components will form the intervention framework. The succeeding chapter (Chapter four) discusses the methodology adopted for the study.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Preamble

This chapter presents the research paradigm and appropriate methodology for achieving the research question and objectives. The research population, sample frame, sample size are also discussed in this chapter. The research aim, questions, and objectives guide the choice of particular research philosophy. Based on the research questions and objectives, the research is designed to adopt both positivism and interpretivism research philosophy; therefore, for this study, only the research strategies employed are explained below.

4.2. Research philosophy

The research philosophy maps the belief that guides the research study's design, the collection, analysis of data, and reporting of findings. It generally relates to the researcher's perception about a topic based on reality, truth, or understanding (Ryan, 2018). The research philosophies that guide psychology-related studies are positivism, pragmatism, or social constructivism (Ryan, 2018). For this research, the objectives involved positivism and interpretivism philosophy. Research tapping into the advantages of positivism and interpretivism philosophies is advised in specific research fields. In the field of public health, primarily occupational health, the pragmatic ideology is advised, especially in studies relating to mental health, stress, and coping strategies, to enable deep insight into a respondent’s thoughts and feelings (see Mazzola et al., 2011).

Pragmatic philosophy opines that knowledge is birth out of consequences, actions, and situations (Creswell, 2009). The pragmatic worldview underpins mixed methods studies. It asserts that the problem is primary, so all necessary methods are applied to enable the understanding of the problem (Creswell, 2009). This philosophical view allows the researcher to draw from quantitative and qualitative assumptions in their research conveniently. An advantage of combining the methods is that qualitative data can be used to elaborate the quantitative study's findings, affording one method's weakness to be balanced by the strengths of the other (Mazzola et al., 2011). The positivism philosophy postulates that in aiding the understanding of any event, the event has to be observed, measured, and supported by evidence (Creswell, 2009). This implies that developed knowledge is based on proper observation and the measurement of reality in positivism philosophy.

Positivism philosophy is the most applied philosophy when research methods are quantitative surveys or experimental (Ryan, 2018). When adopting the positivism philosophy, existing theory guides the design, followed by data collection, after which the results can either agree or disagree with the theory (Creswell, 2009). In the interpretivism philosophy, the aim is to give credence to the participant’s views, based on their work, living setting, or context (Creswell, 2009). It involves the researcher making meaning of the experiences of others rather than relying on theory like in the positivism philosophy (Creswell, 2009). The research methodology adopted in the interpretivism philosophy is the qualitative technique. In interpretivism, a shortcoming of the philosophy is that researchers cannot be entirely separated from their values and beliefs, informing how the data is collected, interpreted, and analyzed.

4.3 Research approaches

The research approaches for the study were birth from the research philosophy and strategies. The research approaches were "quantitative and deductive" and "qualitative and inductive" in line with the positivism and interpretivism philosophy. The strategies adopted were experiments and surveys for the quantitative method and post-survey interviews for the qualitative technique. The study employed deductive and inductive reasoning (Saunders et al., 2009). Deductive reasoning informs quantitative research techniques, while qualitative research techniques follow inductive reasoning. In deductive reasoning, the research begins with theory; the research strategy is mostly centered around testing an existing theory.

What happens when using deductive reasoning is that the researcher finds an appropriate theory to solve the research problem, predictions (hypotheses or propositions) are then made based on the theory, followed by data collection to test the hypotheses or propositions (Ryan, 2018, Saunders et al., 2009). Inductive reasoning is applied in the case of an exploratory study, starting with collecting data to explore a phenomenon to enable the building of theory, usually a conceptual framework (Saunders et al., 2009). When employing inductive reasoning, data is collected to explore a phenomenon, identify themes and explain patterns, to generate a new or modify an existing theory (Saunders et al., 2009).

4.4. Research Design

Research design plays a pivotal connection between theories, research problems, and required data collection (Nachmias and Nachmias, 2008, Zefeiti and Mohamad, 2015). It provides the pathway for data collection and analysis in a study. Several research design frameworks help a researcher plan the understanding of a research process grounded in existing literature and methods, which would enable the relevance and acceptability of research (Creswell, 2009). Hence, the study largely employed purposive and convenience sampling methods to select the research participants with adequate expertise in the construction industry.

4.5 Study Population

This study consisted of construction tradesmen, site supervisors, and experts engaged in building and civil engineering construction projects. The construction projects from where the respondents were sourced are handled by construction firms registered with the Federation of Construction Industry (FOCI), Nigeria. The FOCI member firms were considered to ensure that the respondents could be identified and contacted in an active work environment. For instance, Kumar (2019) advocated that a study design should ensure that the study participants would be identified and contacted.

Table 4. 1: Research objectives and research methods

		Data collection			Data analysis				
	Research Objectives	Questionnaire	Interviews	Experiment	System dynamics	Structural Equation Modelling	Mean / Relative Importance Index	Linear Regression (Multiple regression)	Logistic regression
1	Identify and assess the risk factors for mental ill-health and protective factors for mental health among construction personnel	✓	✓				✓		✓
2	Assess the impact of work pressure in construction on the physiological health of construction personnel			✓			✓	✓	
3	Identify and evaluate potential mental ill-health solutions	✓	✓				✓/✓		
4	Develop a mental ill-health prevention and mitigation intervention framework for the Nigerian construction industry.		✓		✓	✓	✓		
	Remarks	To survey the measures required to achieve each objective and establish the scientific basis for the intervention system	To determine the reasons for employing the protective factors and job resources (i.e., intervention strategies)	A more reliable accurate means to collect data on the effect of work stress on physiological health	To simulate and develop the best fit framework for the final intervention system	To model and quantify the effect of the risk, protective factors, and job resources on mental health	To determine the frequency of impact	(i) It is great at determining linear relationship. (ii) determine the relationship between work stress and sleep	i) To generate the level of impact of the factors on mental ill-health

4.5.1 Federation of Construction Industry (FOCI)

FOCI is a construction industry pressure group started in 1954 by seven foreign construction industry investors with the original intention to protect their interest in the execution of Building and Civil Engineering projects in Nigeria following the Nigerian independence (Federation of Construction Industry, 2019). Over the years, FOCI has grown to comprise indigenous and foreign enterprises and has earned the reference point for regulating the activities of firms engaged in Building and Civil Engineering projects irrespective of professional body affiliation (Federation of Construction Industry, 2019). FOCI maintains a common basis for employees' employment conditions and day work rates within the Nigerian construction industry (Federation of Construction Industry, 2019).

FOCI also ensure that artisans undergo some form of formal or trade education before being employed, while professionals (such as site supervisors/engineers and project managers) need to belong to appropriate regulatory bodies such as the Council of Registered Engineers of Nigeria (COREN) and Council of Registered Builders of Nigeria (CORBON). Based on the level of formalization and structure which FOCI provides for its members, the list of construction companies registered under FOCI has been widely employed for sample size calculation in research relating to the Nigerian construction industry and its workforce. Only construction tradesmen and site supervisors (or engineers) employed by construction firms registered under FOCI were sampled for this study.

4.6 Objective One and Three: Methodology[8]

Questionnaire surveys and post-survey interviews were used to achieve objectives one and three. The questionnaires used for the study were of three categories, tagged questionnaires A, B, and C (see Appendix I, II, III). Questionnaire A was administered to professionals at supervisory level, B was administered to tradesmen, and C was administered to experts (i.e., construction professionals at the top management level). Questionnaire A and B were used to achieve objectives 1, and 3, while Questionnaire C was used to achieve objectives 3. Questionnaire A elicited information on the presence or absence of mental ill-health (depression or anxiety symptoms), causes of stress, resilience, coping strategies, and strategies to improve personnel's mental health. The experts' questionnaire (questionnaire C) solicited information on mental health intervention strategies required in the workplace. The questionnaire was prepared using deductive reasoning based on existing literature and theories.

The questions screening for the state of mental health were adapted from the Patient Health Questionnaire (PHQ-9) and Generalized Anxiety Disorder (GAD-2) while those screening from protective factors will be adapted from the Brief Resilience Scale BRS (Smith et al., 2008), the Ways of Coping Scale (see Folkman et al., 1986) and Leung et al. (2006). The scales were adapted because of the following reasons:

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[8] This section is partially based on the articles below produced by the author of the thesis during the PhD study:
Nwaogu, J. M. and Chan, A. P. C. Under Review. Evaluating How Coping Strategies and Individual Resilience affects Anxiety and Depression among Construction Supervisors. *Journal of Civil Engineering and Management*. SCEM-2021-0043.
Nwaogu, J. M., Chan, A. P. C. and Tetteh, M. O. 2021. Staff resilience and coping behavior as protective factors for mental health among construction tradesmen. *Journal of Engineering, Design and Technology*. https://doi.org/10.1108/JEDT-11-2020-0464.
Nwaogu, J. M., Chan, A. P. C. and Darko, A. Under Review-a. Risk Factors Influencing Mental Ill-health and Suicide Ideation among Construction Tradesmen in Nigeria. *International Journal of Building and Pathology*. IJBPA-11-2020-0098.R1.

(i) the language of the PHQ and GAD questionnaires is simple, easy to understand, and they are fast to administer than other mental health assessment tools (Adewuya et al., 2018);

(ii) unlike other resilience scales, the Brief Resilience Scale (BRS) measures recovery in resilience;

(iii) the WCQ is the most widely used validated questionnaire to measure coping processes and has been applied in varying occupations, cultures, and health concerns (Van Liew et al., 2016).

4.6.1 Research instruments

Rating scales are used in survey studies employing quantitative methodology and various disciplines. In health, psychology, and allied professions, Likert scale rating between two and seven are used (Østerås et al., 2008). Assessment scales like the Short Form 36 (SF-36) Health profile uses 5-point scales while others like the Nottingham Health Profile (NPF) use 2 to 3 point scales, the World Health and work performance questionnaires employ scales 4 to 11 points (Østerås et al., 2008). Two rating scales were employed, for instance, the Ways of Coping Questionnaire (WCQ), the mental health assessment questionnaires (Patient Health Questionnaire (PHQ-9), and Generalized Anxiety Disorder (GAD-2)), which were used in this study are rated in 4-point scales. In contrast, the Brief Coping Inventory (BCI) was rated in 5-point scales. Some authors have argued even scales to be better, while others advocated the use of 7-point Likert scales as best (Østerås et al., 2008).

However, concerns about the difficulty of using suitable adjectives when using the 7-point scale and the loss of information due to the inability of the respondent to differentiate between such adjectives have risen. The 5-point Likert scale, which is the most used type of rating (Jamieson, 2004), has been faulted for the neutral point, which is argued to affect reliability and consistency arising from neutrality and indecision (Weems and Onwuegbuzie, 2001, Kulas and Stachowski, 2009). To avoid neutral point bias, even-numbered Likert scales are encouraged as respondents are forced to take a better position than opting for a neutral point which is mostly the case in an odd point scale (Brown, 2000). Scales with four responses are somewhat quick to use and allow respondents to express their feelings adequately, though they also have their cons (Brown, 2000).

Irrespective of the type of Likert scale adopted, the reliability of responses from a survey is most important (Østerås et al., 2008). Therefore, calculating and reporting Cronbach's alpha coefficient for internal consistency reliability is important. Most scales employ the 4-point as an ipsative item (Kline, 2005).

4.6.1.1 Mental health assessment questionnaires (PHQ-9 and GAD-2)

Using a two-week recall period, the response options on the PHQ-9 and GAD-2 are 0 = "not at all", 1 = "several days", 2 = "more than half the days" and 3 = "nearly every day". The total score for the PHQ-9 ranged from 0 to 27, with a higher score indicating greater self-reported depression. The PHQ-9 uses cut-off point; ≤4 (none), 5 (mild), 10 (moderate), 15 (moderately severe), 20 (severe depression) (Li et al., 2017). A total score of 5-9 indicates minor depression, while ≥10 indicates major depression (Choi et al., 2020, Adewuya et al., 2018). For the GAD-2, the total score ranged from 0 to 6, with a higher score indicating greater self-reported anxiety and a total score of ≥3 indicates anxiety (Hughes et al., 2018). The Cronbach Alpha for the PHQ-9 was 0.78 and 0.79 for supervisors and tradesmen, respectively. Among the respondents, the GAD-2 had Cronbach Alpha 0.72 and 0.83 for supervisors and tradesmen, respectively.

4.6.1.2 Stressor instrument

The stressor questions were developed by adapting mental ill-health significant work-related stressors reviewed in Chan et al. (2020) and non-work stressors identified in Sunindijo and Kamardeen (2017). In this section, respondents were required to indicate the occurrence frequency of each stressor on a four-point Likert scale: 1 = "never", 2 = "very little", 3 = "moderately", and 4 = "very great". The stressor instrument differed among the two categories of personnel owing to the uniqueness of their job. For instance, supervisors' duties are more mentally demanding, while tradesmen engage in more physically demanding jobs (Nwaogu and Chan, 2021b). The stressor instrument contained 38 and 33 stressor questions for supervisors and tradesmen, respectively. The Cronbach Alpha for the stressor instrument was 0.81 and 0.90 for supervisors and tradesmen, respectively.

4.6.1.3 Brief Resilience Scale (BRS)

The BRS is a psychometric measure containing six items used to measure resilience. Three of the questions (item two, four, and six) are reverse coded to indicate pessimism, while the remaining questions (item one, three, and five) are positively coded, indicating positivism. The response options on the BRS are: “strongly disagree” = 1, “disagree” = 2, “neutral agree” = 3, “strongly” = 4, “agree” = 5. The scale employs cut-off points ranging from 1.00 to 5.00, where 1.00 to 2.99 shows low resilience, normal resilience ranges from 3.00 to 4.30, and 4.31 to 5.00

indicates high resilience (Smith et al., 2013). The Cronbach Alpha for the BRS was 0.75 and 0.72 for supervisors and tradesmen, respectively.

4.6.1.4 Coping strategies instrument

The Ways of Coping Questionnaire (WCQ) was used to develop the coping strategies instrument. The WCQ consists of 66 items measuring the extent to which respondents employed each coping measure in the face of stress (Scherer and Brodzinski, 1990). Following a review of existing literature (Liang et al., 2018, Haynes and Love, 2004, Chan et al., 2014, Leung et al., 2006) and a pilot study, a total of 26 coping behaviors (skills) questions were adapted from the WCQ. Coping behaviour is measured on a four-point Likert scale indicated by 0 = "never", 1 = "very little", 2 = "moderately", and 3 = "very great". The Cronbach Alpha for the WCQ was 0.74 and 0.76 for supervisors and tradesmen, respectively.

4.6.1.5 Strategies for mental health promotion

The research instrument is an online administered questionnaire developed by adapting 31 strategies for mental health promotion recommended in previous studies (Enns et al., 2016, Gullestrup et al., 2011, Tan et al., 2014, Pignata et al., 2018, LaMontagne et al., 2014, Burke, 2019). The respondents were required to indicate their level of agreement with each strategy on a four-point Likert scale with 1 = I strongly disagree; 2 = I disagree; 3 = I agree; 4 = I absolutely agree. The strategies are contained in Questionnaire C (see Appendix III).

4.6.2 Face and Content Validity of Questionnaire

Four experts conducted the face and content validity on the draft questionnaire using a two-stage review process. The experts consisted of occupational health psychologists and construction professionals. Each of the occupational health psychologists has over 20 publications and serves as directors in Construction Health Research Institutes. The construction professionals include an Associate Professor and a Professor with numerous publications. All the panelists were sourced based on the relevance of their publications to construction health and safety, particularly mental health. The draft copy of the questionnaire was sent to two construction professionals, and their feedback was used to arrive at an improved draft questionnaire. The improved draft was sent to another panel consisting of two occupational health psychologists.

The reviewers' comments include "this is a neutral statement while the others are negative statements. Please consider to be more specific", "Unfinished sentence. Do you mean poor living condition at home?". Therefore, the neutral question "task autonomy" was changed to "low task autonomy," and living condition marked as an incomplete sentence was adequately improved, "Are these from a validated depression and anxiety scale? If so, then they're ok", change the instruction to "over the last two (2) weeks, how many days have you experienced the following issues?" and "don't put the stressors in categories."

Upon final approval, the questionnaire was pilot tested among fifteen site-based construction personnel registered with the Nigerian Institute of Civil Engineering (NICE), Nigerian Institute of Building (NIOB), Nigerian Institute of Architects (NIA), and Nigerian Institute of Quantity Surveyors (NIQS). The personnel were asked to comment on their understanding of the questions and the time required to complete the survey. All participants indicated that they understood the questions and took approximately fifteen minutes to complete the questionnaire.

4.6.3 Sampling Design and Frame

An accurate sampling frame in data collection is essential to avoid bias which can occur when the sample is not representative of the general population. Therefore, a sample frame helps to achieve a population from which sample size can be drawn to achieve a generalizable result (Kumar, 2019). Going by the explanation of Kumar (2019), in the context of this work, the sample frame refers to the list identifying every construction firm or professional body from which the respondents will be drawn.

4.6.3.1 Sampling design and frame for objective one

For the achievement of objective one, the sample frame was drawn from FOCI and included the list of all construction firms engaged in Building and Civil Engineering projects. The purposive sampling method was employed to identify the firms from which the supervisors and tradesmen for the achievement of objective one were sampled. A total of 85 firms were identified from the FOCI directory of full members. According to the Federation of Construction Industry (2019), a company is considered a full member if she satisfies the following conditions: (i) undertakes Building or Civil Engineering contracting in Nigeria, (ii) has one vote at its Annual General Meeting; (iii) eligible for election in one of the ten seats on the Council; (iv) pays an annual subscription based on the value of contracts the company undertakes.

4.6.3.1.1 Sample size for objective one

There is a need to determine a sufficient and representative sample size from the study frame. From the 85 firms identified, the number of study participants recruited was arrived at using a mathematical formula (see Equation 4.1). It is important to note that although the number of firms to be visited is known, the respondents' sample size is yet to be deduced. To determine the respondents' sample size, the formula for determining the sample size for continuous data cited in Sunindijo and Kamardeen (2017) was employed. This formula is employed since the number of employees engaged as site supervisors, and construction tradesmen is unknown.

Sample size, $n = \frac{(t)^2 \; x \; (s)^2}{d^2}$ ………………………………………………… (Equation 4.1)

n = Sample size

t = 1.96 (i.e., confidence level based on the value of selected alpha level of 0.025 in each tail)

s = estimate of variance deviation of the 4-point Likert scale used (i.e., number of points on the scale divided by the number of standard deviation)

d = margin of error for the estimated mean (i.e., number of points on the 4-point Likert scale = 4; multiplied by the acceptable margin of error = 5%).

According to Bartlett et al. (2001), the "**s**" equals the number of points on the scale, which is 4, divided by the number of standard deviation (in this scale equals 4), being two to each side of the midpoint of the range). Upon the division, the value of "**s**" equals 1. By using equation 4.1, the sample size is calculated as 96 survey participants.

$$n = \frac{(1.96)^2 \; x \; (1)^2}{(4 \; x \; 0.05)^2} = 96$$

The total sample size for the respondents represents the minimum number of responses to yield a representative response. Since this study consists of two different groups of employees, a minimum of 96 tradesmen and 96 construction site supervisors were expected to be sampled.

4.6.3.2 Sampling design and frame for objective three

For the achievement of objective three, the respondents included experts and supervisors. While the supervisors have been discussed in objective one, the experts included construction practitioners involved in health and safety, relation-building, and policy-making in the construction workplace. In order to identify the experts to survey, convenience and purposive sampling were employed. The basic requirement for getting the appropriate experts was to liaise with the professional bodies in the Nigerian construction industry. The professional bodies, which usually have their members in key professions on the construction site, were contacted. Those organizations include the Nigerian Institute of Building (NIOB), Nigerian Institution of Civil Engineers (NICE), Nigerian Institute of Architects (NIA), and Nigerian Institute of Quantity Surveyors (NIQS). In order to increase the relevance of the findings, the respondents to be recruited had to meet four criteria: (i) must be an industry practitioner; (ii) occupy corporate, or fellow membership position; (iii) occupy a management position in a construction firm or own a construction firm; (iv) must be involved in health and safety planning and management in the Nigerian construction industry.

4.6.3.2.1 Sample size for the expert survey

The professional organizations were contacted and briefed on the intention of the research. Thereafter, the study was advertised among suggested members of professional organizations. A total of 45 respondents who met the criteria and gave their informed consent to participate in the survey formed the survey respondents. Therefore, purposive sampling was adopted for this study. All participants had over 29years of experience and included Presidents of the professional bodies, Managing Directors, Head of health and safety, operations, and human resource managers. A total of 45 duly filled questionnaires were retrieved from the experts. Although the subject of making the workplace psychologically healthy and safe seems a general concern that any construction professional can answer, it is not, considering the complexity of the construction workplace.

In order to arrive at a realistic mix of strategies that can be implemented, the opinion of practitioners who have moved up the ladder and presently occupying critical decision influencing positions with regards to construction planning, health, and safety in the construction industry proved most reasonable. The 45 responses are considered adequate following the central limit theorem, which holds that a sample size of 30 is sufficient for statistical analysis (Darko et al., 2017b, Chan and Adabre, 2019). Likewise, 45 responses were adequate considering previous research, which has employed expert opinion in decision and policy-making in the construction industry studies. For example, Darko and Chan (2018), Ameyaw and Chan (2016), and Darko et al. (2017b) were based on 33, 40, and 43, respectively.

4.6.4 Data analysis techniques

After testing the normality of the data collected, the data were analyzed using either parametric and non-parametric techniques. Overall the data from the survey were non-normal because of the ordinal nature of the responses. Therefore, in the case of conducting a test between responses, non-parametric tests were employed. Likewise, analytic methods appropriate for non-normal data were used for data analysis. Parametric tests are used for analyzing data that are normally distributed. In contrast, if the data are skewed to one direction or the sample size is small, the non-parametric test is employed (Ali and Bhaskar, 2016). Parametric method is mostly employed for continuous or interval data, while non-parametric method is applied to ordinal data such as the Likert scale (Mircioiu and Atkinson, 2017). However, studies have shown that the parametric method can be applied to continuous data and ordinal or nominal scale data (Hwang et al., 2014, Zhao et al., 2016b, Sullivan and Artino Jr, 2013).

4.6.4.1 Chi-square tests (χ^2) or Fisher's exact test

Chi-square tests (χ^2) test is a non-parametric test used in clinical research. It is used to test hypotheses when the variables are nominal, provides information on the significance of any observed differences, and provides information on exactly which categories account for the differences (McHugh, 2013). In this research, Chi-square test (χ^2) was used in objective one to explore the statistical significance and differences between resilience, mental ill-health groups, and demographic characteristics. In a case where the expected number of frequencies in a cell is fewer than five during the Chi-square, the Fisher exact test value was recorded (Kroonenberg and Verbeek, 2018).

4.6.4.2 Kruskal-Wallis test

Kruskal-Wallis test is a non-parametric test used to assess the differences among three or more independently sampled groups (McKight and Najab, 2010). The null hypothesis (H_0) holds that "there is no difference in the mean ranks of the groups" with a significance level of 0.05. If the p-value is less than 0.05, the H_0 is rejected, indicating a statistically significant difference in the means. Kruskal-Wallis test was used in objective three to determine whether the experts' opinions on the strategies for improving mental health differed among the professional groups. The Kruskal-Wallis test holds that if the ρ value is greater than 0.05, there is no statistically significant difference in opinions for the strategies.

4.6.4.3 Mean score ranking

Mean score analysis was used to rank the risk factors, protective factors, and intervention strategies to determine their perceived intensity. Mean score analysis is the most common descriptive statistics and used with standard deviation (SD) or standard error of mean where ranking is needed. The technique of mean score is employed to determine the most significant factors or strategies influencing a study (Sullivan and Artino Jr, 2013). Mean score was employed in objectives one, two, three, and four.

4.6.4.4 Relative importance index

In addition to the mean score, the relative importance index (RII) technique was used to describe the intervention strategy's relative importance in enhancing mental health in the construction industry. Although RII is a descriptive analysis, which can be used to determine perceived impact, unlike the mean score, RII ranges from 0 to 1 and reflects the relationship between the individual components (Chan and Kumaraswamy, 1997). The higher the index, the more critical the impact of the strategy. RII is determined using Eqn. (4.2):

$$\text{RII} = \frac{\sum W}{A * N} \qquad 0 < \text{RII} \leq 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(4.2)}$$

Where, A is the highest Likert weight (i.e., 4); W is the weighting allocated to each strategy by the respondent (ranging from 1 to 4) and N is the total number of respondents. Three levels of importance were transformed from the RII as shown in Aghili et al. (2019): high importance $0.8 < \text{RII} \leq 1.0$, medium importance $0 .5 < \text{RII} \leq 0.8$, low importance $0 < \text{RII} \leq 0.5$.

4.6.4.5 Fuzzy synthetic evaluation (FSE) technique

Fuzzy synthetic evaluation (FSE) is an objective evaluation approach based upon using the fuzzy set theory to quantify the linguistic facet of given data for effective decision making (Zhao et al., 2016a). FSE is a multi-decision making evaluation technique used to remove uncertainty, imprecise data related to decision-making involving different players (Ameyaw and Chan, 2016). The FSE has been adopted in several academic fields, including construction risk management (see Zhao et al., 2016a, Wu et al., 2017, Ameyaw and Chan, 2016), and health management (see

Sadiq and Rodriguez, 2004). Usually, the opinions of respondents on the level of impact of any factor are contemplated as subjective (Owusu et al., 2019).

Since FSE has the potential to objectify the opinions of the experts, it was employed in this research to determine the strategies that will best improve the mental health of construction personnel. As shown in Ameyaw and Chan (2016), and Owusu et al. (2019), the procedure for carrying out FSE in strategy assessment involves the steps outlined below:

(i) Build the principal factors/strategies

(ii) Set up an assessment index system

(iii) Determine the membership grade of the variables (first level)

(iv) Calculate the weighing functions of the variables

(v) Building the multi-criteria and multi-level FSE model

(vi) Estimate the overall importance index of the STCs

4.6.4.6 Logistic regression analysis[9]

In the analysis of medical and psychological data, regression analysis is an essential statistical method. When working on medical and psychological data, regression analysis enables the assessment of relationships existing among multiple factors, identifying prognostically relevant risk factors, and calculating risk scores (Schneider et al., 2010). Regression analysis describes the relationships between the dependent and independent variables in a simplified

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[9] This section is largely based on the articles produced by the author of the thesis during the PhD study:
Nwaogu, J. M. and Chan, A. P. C. Under Review. Evaluating How Coping Strategies and Individual Resilience affects Anxiety and Depression among Construction Supervisors. *Journal of Civil Engineering and Management*. SCEM-2021-0043.
Nwaogu, J. M., Chan, A. P. C. and Tetteh, M. O. 2021. Staff resilience and coping behavior as protective factors for mental health among construction tradesmen. *Journal of Engineering, Design and Technology*. https://doi.org/10.1108/JEDT-11-2020-0464.

mathematical form using a model (Schneider et al., 2010). Logistic regression is a type of regression used for analyzing the probability of an event occurring over not occurring, with the impact of independent variables on the dependent variable (Park, 2013). Two assumptions hold for logistic regression and relate to the nature of the distribution and nature of the relationship (Menard, 2002).

In the logistic regression model, the unit of analysis can be the individual subject or the circumstances in the group. It fits appropriately for describing the relationship between categorical outcome variables or continuous predictor variables. In logistic regression, an odds ratio (OR) greater than one (OR >1) indicates increased occurrence of an event (i.e., risk factor), OR <1 indicates reduced occurrence of an event (i.e., protective factor), and OR=1 indicates that there is no effect on the occurrence of outcome (Szumilas, 2010). In analyzing mental ill-health symptoms, the respondents were classified into two groups each (depression versus no depression, anxiety versus no anxiety), as shown in Li et al. (2017). Additionally, other group classifications required are itemized alongside the dichotomous coding. For logistic regression, the dichotomous coding was coded as follows:

(i) Depression versus no depression- participants were categorized as "depression" if they had PHQ-9 scores ≥ 5. Therefore, the “depression” group (PHQ-9 scores ≥ 5) was coded as 1, while “no depression” group (PHQ-9 scores < 5) was coded as 0.

(ii) Anxiety versus no anxiety- participants were categorized as "anxiety" if they had GAD-2 scores ≥3. Therefore, the “anxiety” group (GAD-2 scores ≥ 3) was coded as 1, while “no anxiety” group (GAD-2 scores < 3) was coded as 0.

(iii) Suicidal ideation versus no suicidal ideation- participants were categorized as "suicidal ideation" and coded as 1, if they ticked two or above on item 9 of the PHQ-9, indicating "an experience of suicidal ideation". A response indicating "not at all" was classified as "no suicidal ideation" and coded as 0.

(iv) BRS score ≥ 4.31, 3.00-4.30, 1.00-2.99 were used to categorize participants as "high resilience", "normal resilience", and "low resilience," respectively. However, for moderation analysis and determine the reciprocal relationship between resilience and coping strategies, BRS ≥ 4.31 and 3.00-4.30" were re-coded as 1 (i.e., Resilient/high); 1 = 1.00-2.99 was coded as 0 (i.e., Not resilient/low). The re-coding was done to satisfy the conditions for the analysis.

(v) For coping strategies, "strongly disagree" = 0 was coded as 0 (i.e., No); 1 = "*very little*", 2 = "*moderately*", and 3 = "*very great*" were combined and coded as 1 (i.e., Yes).

(vi) For stressors, 1 = "never" was coded as 0 (i.e., No), while 2 = "very little", 3 = "moderately", and 4 = "very great" were combined and coded as 1 (i.e., Yes).

4.6.4.6.1 Univariate logistic analysis

Univariate logistic analysis was employed for achieving objectives one and two. Logistic regression evaluates how binary outcomes are affected by explanatory variables (Bonney, 1987). Univariate logistic regression analysis is appropriate for modeling the effect of one independent variable on a dependent variable. In contrast, multivariate analysis (e.g., multiple logistic regression) models the influence of a set of independent variables on a dependent variable (Park, 2013). Univariate logistic regression is appropriate for modeling the effect of an independent variable on a dependent variable. Thus, univariate logistic regression analysis was used to indicate where to direct potential effective interventions targeted towards reducing stress for improved mental health in the construction industry.

4.6.4.6.2 Multivariate logistic regression

This type of logistic regression was employed to deduce the protective factors since most individuals use a mix of them at once (Biggs et al., 2017). Using a cut-off value of $p < 0.25$ as recommended by Bursac et al. (2008) and Cheung and Yip (2015), all independent variables with a p-value of less than 0.25 in the univariate analysis were selected as a candidate for the multiple logistic regression. The multivariate logistic regression models were used to explore the cluster of coping strategies and resilience that protect against depression and anxiety. The multivariate logistic regression analysis began by using forward likelihood ratio (LR) to estimate the relationship between the independent variables (resilience and coping strategies) and the dependent variables (mental ill-health symptoms). Afterwards, the significant variables were combined in the final model and analyzed using the 'enter' method. Hosmer-Lemeshow test at $p > 0.05$ was used to analyze the goodness fit of the multiple logistic regression model (Hosmer and Lemesbow, 1980, Choi et al., 2020). The SPSS statistical package 20.0 was used to perform all the analyses.

4.6.4.7 Conditional process analysis (CPA)

Conditional process analysis (CPA) is a regression-based approach used to test the mediation and moderation hypothesis using the Haynes PROCESS macro add-on tool (version 3.5) for SPSS (Hayes, 2017). The CPA is based on ordinary least square regression or multiple logistic regression path analytic framework (Langdon and Sawang, 2018). It was used to test if resilience mediates or moderates the path between coping strategies and mental health. Mediation analysis is used to examine whether a direct or indirect pathway exists through which a coping strategy transmits its effects on mental health through resilience; moderation analysis examines how the effect of a coping strategy on mental health depends on resilience (Hayes, 2017).

4.6.5 Semi-structured Interviews[10]

Semi-structured interviews were employed in objectives one, two, and three on a post-survey interview basis to assess the findings and gain better insights into the study (see Hwang et al., 2020). The post-survey interview population involved five to ten respondents who partook in the survey and indicated a further interest in the research. For each objective, the survey results alongside a brief explanation were provided to the respondents. The interviewees were asked to assess and give their suggestions on the findings with reference to the study's aim and objective.

The post-survey interview lasted for about 30minutes, and thematic analysis was used to elucidate the findings. For objective one, the interview questions included:

(i) In your opinion, why do you think the tradesmen who work in micro firms were more likely to be anxious than those who worked in larger-sized construction firms?

(ii) Why do you think that tradesmen with experience less than 20 years and older than 25 years appeared to be more likely to experience depression or anxiety?

[10] This section is partially based on the article below produced by the author of the thesis during the PhD study: Nwaogu, J. M., Chan, A. P. C. and Darko, A. Under Review-a. Risk Factors Influencing Mental Ill-health and Suicide Ideation among Construction Tradesmen in Nigeria. *International Journal of Building and Pathology*. IJBPA-11-2020-0098.R1.

(iii) The analysis showed that people who work in construction firms with more complex organizational structures were more prone to depression or anxiety than others. What do you think is the reason(s) for that?

4.7 Objective Two: Methodology[11]

An experimental procedure was employed to gather data to achieve objective two (see Table 4.2). The study employed a wearable electrocardiogram (ECG) device and wrist activity tracker to determine the relationship between work pressure and sleep.

4.7.1. Research instruments for the experimental procedure

To collect data for this study, two wearable devices that previous studies had validated were employed. The two wearable devices selected are 1) Polar H10 heart rate monitor manufactured by Polar Electro Oy, Finland, and 2) Fitbit Alta HR activity tracker. Before settling to use the devices, a pilot study was conducted to ascertain the devices' feasibility.

4.7.1.1. Polar H10 heart rate monitor

The Polar H10 heart rate monitor is a chest-worn ECG-based sensor, Bluetooth compatible training device capable of recording HRV non-intrusively, utilized in sports, medicine, and other

[11] This section is largely based on the article below produced by the author of the thesis during the PhD study: Nwaogu, J. M. and Chan, A. P. C. 2021b. Work-related stress, psychophysiological strain, and recovery among on-site construction personnel. *Automation in Construction,* 125**,** 103629. https://doi.org/10.1016/j.autcon.2021.103629.

fields (Gamelin et al., 2006). The Polar H10 is a reliable instrument for HRV measurement and has been utilized in a validation study on its efficacy (see Tibana et al., 2018) because its R-R interval agrees with standard ECG equipment (Gilgen-Ammann et al., 2019). The R-R refers to the time elapsing between two consecutive R-waves in an electrocardiogram (Gilgen-Ammann et al., 2019). The R-R interval measures little changes in intervals between heartbeats (i.e., peak to peak interval between the R waves), unlike the heart rate that averages the number of beats per minute (Shaffer and Ginsberg, 2017). In this study, the data from Polar H10 was visualized using a smartphone application called Elite App and downloaded for further analysis using the Kubios HRV software by Kubios, Finland (Speer et al., 2020).

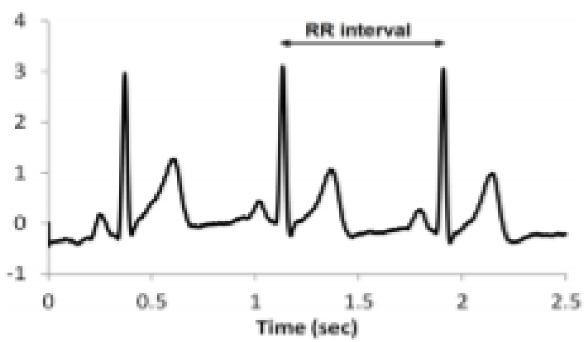

Figure 4. 1 A schematic illustration of the RR interval on a typical ECG signal.

4.7.1.2. Fitbit Alta HR activity tracker

The Fitbit Alta HR is a commercially available activity-tracking device based on actigraphy that offers low cost and non-intrusive method to objectively collect data on sleep quantity and quality (Hamill et al., 2020, Lee et al., 2018). The Fitbit Alta HR manufactured by Fitbit Incorporated syncs data collected to the Fitbit app using Bluetooth function. Fitbit Alta HR has been found to provide a satisfactory result when collecting sleep quality data in a home setting (Hamill et al., 2020). Sleep data collected by the Fitbit device include total sleep time (TST), time in bed (TIB), light sleep (N1+N2), deep sleep (N3), wake after sleep onset (WASO), and rapid eye movement (REM). The data collected using the Fitbit Alta HR activity tracker was assessed through the Fitbit cloud.

4.7.2. Recruitment of participants

A total of 56 healthy adult male participants engaged as construction personnel (i.e., 28 skilled tradesmen and 28 site supervisors/engineers) were recruited for the study. The personnel were engaged in activities related to their job duties, as described in Table 4.2. The rule of thumb was used to determine the sample size for the study. In the construction industry, prior studies using wearables to gather physiological data sampled between two to eleven participants (Jebelli et al., 2018a, Shen et al., 2017). The participants were sourced from 14 medium-sized construction firms in Lagos state and Abuja, Nigeria, by contacting the project managers about recruiting prospective participants from any of their worksites. For each firm, after the project manager approved the experiment, access was provided to an assigned project site. The access commenced with a meeting arranged with willing participants. The aim of the study and experimental procedure was explained to the personnel. Only personnel who volunteered to participate in the experimental process were recruited.

The volunteers were screened based on lifestyle and health status information collected, upon which only healthy personnel were recruited. Thereafter, successful participants were given informed consent to study and append their signature. Although alcohol consumers have been eliminated in their study previous studies (Föhr et al., 2016), alcohol consumption was initially deemed significant to this study as alcohol consumption is part of the construction industry's culture, especially among tradesmen (Roche et al. 2015). However, following the recruitment process and noticing a disproportionate amount of alcohol consumers among the volunteers, only non-alcohol consuming personnel were chosen to participate in the experimental procedure.

Table 4. 2: Description of participants' work tasks and work location

Job positions/trades	Repetitive activities	Work location
Supervisors	Administrative work in the site office, worksites within estate development, monitoring and controlling work activities	Indoor and outdoor
Tradesmen		
Masons	Plastering of an interior wall, and block laying of a perimeter fence, and laying superstructure block wall	Indoor and outdoor
Tiler	Surface preparation, sorting, and laying of tiles on floors and wall	Indoor
Iron bender (rebar worker)	Reinforcement sorting, bending, and fixing	Outdoor
Concreter	Organizing the placement of ready-mix concrete in sub-structure and leveling the concrete	Outdoor
Carpenter	Removing of suspended floor formwork, transfer, and installing formwork for cast-in-situ.	Indoor
Plaster of Paris (POP) fixer	Preparing and fixing POP suspended floor	Indoor

4.7.3. Data collection

The daily experimental procedure commenced by briefing the participants about the process, how to strap the Polar H10 on their chest, and wear the activity tracker on the wrist. The purpose of the experiment, which is to improve health and well-being, was reinstated to the participants to reduce Hawthorne effect error. Hawthorne effect error undermines the research findings and occurs when study participants change their behavior because they are being observed (Hwang and Lee, 2017). Information on sleep quality was gathered using the activity tracker as participants slept in their homes. On each experimental day, a reminder text message was sent to personnel around 8 pm to remind them to wear the tracker properly before going to bed. In this study, HRV and sleep data were collected from twenty-eight tradesmen and site supervisors (i.e., engineers).

The data was collected between December 3, 2019, and January 25, 2020, from 14 construction sites engaged in property development. The study was approved by the Hong Kong Polytechnic University Human Subjects Ethics Sub-Committee (Reference No. HSEARS20190916001) (see Appendix XII). Finally, to assess sleep habits and gain better insights into some factors that may influence sleep duration, a post-experiment interview was conducted with ten participants (five supervisors and tradesmen) who partook in the experiment.

4.7.3.1. Heart rate variability and sleep data

Before the experiment commenced on each participant, demographic information such as age, height, and weight were collected. The heart rate monitor was strapped to the chest of the participant and paired to the Elite App through Bluetooth from where the HRV reading was accessed (see Speer et al., 2020). Upon wearing the device, the subjects were instructed to rest by sitting down for exactly 10minutes to determine their resting HR. Thereafter, the lowest heart rate recorded was deemed resting HR, as described in Tibana et al. (2018). After collecting the resting HR, the participant puts the smartphone in a close range to avoid disconnection and carries on his work. The HRV data were collected as participants carried out their assigned work for approximately 2hour 30minutes in the afternoon. After the stipulated time, the R-R interval data in the form of text file were exported to a Matlab-based software Kubios HRV to analyze HRV parameters. The Fitbit Alta HR was worn on the wrist while sleeping in the participant's home. On the following day, the wrist was paired with the Fitbit smartphone app, and the sleep data in the form of an excel file were exported for analysis.

4.7.4. Data analysis methods

As a first step, since the HRV data were collected while working, it was necessary to clean signal artifacts caused by movements and noise. However, the rule of thumb for artifact correction holds that the correction required should not be more than 5% of the dataset. Given the threshold, a strong level of artifact correction was found appropriate and applied. Thereafter, to achieve the research objectives, the following analytical methods were employed for the HRV and sleep data:

(i) Descriptive statistical methods, particularly mean score and standard deviation, Pearson product-moment correlation coefficient, and inter-group comparison tests using SPSS 20.0 statistical package.

(ii) Linear and multiple regression using open-source R software.

(iii) Finally, the post-experiment interviews were analyzed using narrative synthesis.

4.7.4.1. Data normality test

Prior to data analysis, information about the normality of the collected data is essential. The data normality was diagnosed using (i) Shapiro-Wilk test and (ii) checking for skewness and kurtosis. Non-normally distributed *deep sleep data* was transformed using a two-step approach for transforming continuous variables to normal (Templeton, 2011). With the two-step approach, the variable is first transformed into a percentile rank, resulting in uniformly distributed probabilities. Thereafter, the inverse-normal transformation is applied to the results from the previous step to form a variable consisting of normally distributed z-scores (Templeton, 2011). Given that the sample size is above 50, the Kolmogorov-Smirnov test of normality only could be employed (Mishra et al., 2019).

However, because of the slight discrepancies between Shapiro-Wilk and Kolmogorov-Smirnov tests (see Table 4), affecting checking the histogram and Q-Q plots, this study used the Shapiro-Wilk tests to mitigate a Type II error. For both tests, the null hypothesis assumes that the data are normally distributed with alpha value at 0.05 (Darko and Chan, 2018); if the p-value is lower than 0.05, the null hypothesis is rejected, and data is non-normal. Upon transformation, the data were re-tested for normality, and the data satisfied normal distribution.

4.7.4.2. Descriptive statistics and inter-group comparison

The commonly used descriptive statistics, mean and standard deviation (Mishra et al., 2019) were used to determine the average HR, HRV, and sleep data among the group of participants. Given that the participants are of two major construction personnel groups (tradesmen and supervisor), it was important to check if the data collected had any significant differences between the group. The Mann-Whitney U test and independent T-test were employed to conduct the inter-group comparison on the data collected for determining statistical differences. Mann-Whitney U, a non-parametric test, was considered for non-normally distributed, while Independent T-test, a parametric test, was employed for the normally distributed data.

The Mann-Whitney U test does not make any normality distribution requirements about the population (Darko et al., 2017a). The null hypothesis in the Mann-Whitney U test holds that “there is no difference amongst two groups” with a significance level of 0.05. If the p-value is less than 0.05, the null hypothesis is rejected, and the alternative hypothesis is accepted, indicating that there is a statistically significant difference in the means. Independent T-test relies on the assumptions of normality of the population and homogeneity (Nguyen et al., 2016). The independent t-test helps to compare the means of two independent samples. Similar to the Mann-Whitney U test, the null hypothesis in an independent t-test holds that “there is no difference amongst two groups.” With a significance level of 0.05 for independent t-test, if the p-value is less than 0.05, the H0 is rejected, and the alternative hypothesis is accepted (Sheskin, 2011).

4.7.4.3. Spearman's rank correlation coefficient

Spearman's rank correlation coefficient is a non-parametric measure of the strength and direction of the relationship that exists between two parameters (Hwang and Lee, 2017). With the significance level (α) set at 0.05, the relationship between the stress index and %HRR was examined. If a correlation is found, the stress index can quantify the intensity of the work engaged in by construction personnel.

4.7.4.4. Multiple linear regression analysis

Linear regression investigates the linear relationship between a continuous dependent variable (Y) and one or more independent variables (X) (Schneider et al., 2010). In this study, multiple regression analysis was used to estimate the effects of work pressure on physiological health by developing a model to determine the relationship between HRV and sleep quality. Thereafter, two predictive models were developed by training the datasets. The first predictive model forecasts overall sleep quality following work to enhance proper sleep management techniques necessary to boost adequate recovery from daily stress. The second predictive model was developed as a handy tool for estimating the overall sleep quality given subjected sleep score by personnel who may not have an activity tracking device.

The models were developed using R-software. The independent variables were checked for multicollinearity using the Variance Inflation Factor (VIF $\leq$ 10) to ensure the data do not violate the assumption of no collinearity (Salmerón et al., 2018). In a case where the independent variables violated the assumption, correlation analysis was used to identify the possible independent variables to eliminate. The following equation expresses the multiple regression model:

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + ... + \varepsilon \quad \text{(Equation 4.3)}$$

Where, Y = value of the dependent variable; α = the constant (the intercept); β = estimated regression coefficients for each independent variable; x = values of the predictor or independent variable; ε = error term.

Table 4. 3: Typical daily protocol on assessing the effect of work stress on physiological health

Time	Task	Information to be collected	Instrument
1.00pm-1.15pm	Explain the experimental process to each participant (1 participant per day)		
	Collect demographic information	Bio-data Lifestyle information (e.g., alcohol consumption, smoking)	
1.20pm-01.40pm	Collect personal parameters on weight and height;	Body Mass Index	Weighing Scale and Tape
	Set up a mobile app for tracking the physical activity of the participants	HRV data and monitoring	Elite App
1.40pm-1.45pm	Wear ECG chest strap for 2 hours throughout the work process	HR, HRV, and PA	Polar H10 and Elite App
1.50pm– 4.50pm	Working time (3 hours) • On-site data collection as tradesmen performs their job • A video recording to enable a proper analysis of change in positions	Mental stress and physiological stress	Track reading on Polar H10 using Elite App
*4.55 – 5.00	Transfer data from Elite App and prepare for second session/break period for tradesmen		Kubios software
Overnight	Wear activity tracker when going to sleep at night Collect the wrist tracker on the following day and transfer reading	Sleep quality to identify fatigue and sleep problems	Activity tracker (Fitbit Alta HR)
	Repeat procedure for the previous day.		

Note: *HRV readings taken more than one hour would require a longer processing time to generate data used for time and frequency domain analysis.

4.8 Objective Four: Methodology

Objective four which is the final objective of this research, was achieved by harnessing the results of the preceding objectives.

4.8.1 Structural Equation Modelling

The structural equation modeling (SEM) analytical technique can test hypotheses to establish the relationship between items and perform confirmatory factor analysis (CFA). Since the sample is less than 250, the partial least square (PLS/SEM), which can handle a smaller sample size, was employed for this analysis. After sketching the model in the PLS/SEM environment, analysis begins by deducing the path coefficients. The analysis involves eliminating all strategies and stressors in the model whose factor loading is below the threshold of 0.5 (Hair Jr et al., 2016). This process also aids in ensuring that the construct reliability and discriminant validity of the items within each construct met minimum requirements. Cronbach alpha or composite reliability scores at $\geq$0.70 and >0.70 and average variance extracted (AVE) scores at $\geq$0.50 were used to assess the construct reliability and validity (Darko et al., 2018, Hair Jr et al., 2016). As earlier described, Cronbach's alpha or composite reliability scores are used to determine internal consistency, while AVE reveals the construct's convergent validity. According to Henseler et al. (2015), "AVE indicates the mean amount of variance that a construct explains in its indicator variables relative to the overall variance of the indicators."

Discriminant validity ensures that the items in a construct measure do not correlate too highly with another item (Henseler et al., 2015). Henseler and colleagues asserted that if discriminant validity is not fulfilled, the accuracy of results confirming the hypothesized structural paths may not be certain. The discriminant validity of the items was assessed using the Heterotriat Monotrait (HTMT) criterion at threshold <0.85 (Henseler et al., 2015). After confirming the construct reliability and discriminant validity, the path coefficients and effects of the strategies on stressors and the hypothesis were tested using bootstrap analysis. The number of bootstrap samples was set at default (5000) to reduce the result's variations when run again. The decision on the hypothesis were based on t-values threshold for two-tailed test: 2.58 (at significance level = 0.01), 1.96 (significance level = 0.05) and 1.65 (significance level = 0.1). The R-square, coefficients of p-value, and path coefficients were used for the structural model.

4.8.2 System Dynamics

System dynamics was used to develop a sustainable intervention for mental health among construction personnel over time. It is a great tool to use when creating feedback theory (Luna-Reyes and Andersen, 2003). It was used to assess feedbacks on intervention strategies from supervisors. Though system dynamics rely on quantitative data, qualitative data also plays a central role in simulating the modeling process (Wu et al., 2016). System dynamics is a decision-making tool as it allows for exploratory analysis of the state of an intervention by eliciting stakeholders' opinions and modeling the same to determine the best way for a sustainable intervention (Jalali et al., 2017, Kunc, 2016). The building of the system dynamics model (SDM) involved several steps, such as: establishing the system boundaries, developing a causal loop diagram through an iterative process, developing stock-flow diagrams and equations for the simulation. This SDM included multimodal (i.e., primary, secondary, and tertiary) intervention strategies to compare the single and combined effects of the strategies in mitigating or preventing poor mental health in the construction industry.

4.8.2.1 Model construction for system dynamics modeling

The model construction involved an expert discussion session with six project managers. Following the descriptive statistics and logistic regression analysis, a causal loop diagram indicating the risk factors for mental ill-health, the interventions to mitigate or prevent them and ameliorate mental ill-health over time was developed. Further refinement of the loop diagram was conducted with the project managers to analyze the feedback loop critically. After several iterations between the panelists on the feedback loops' accuracy, a final causal loop diagram that conceptualizes the system was agreed upon and developed into a stock and flow diagram using the Vensim software.

4.9 Chapter Summary

This chapter discussed the methodology that was adopted to collect data on the study. The sample frame and size of the study were explained in this chapter. The experimental procedure used to objectively collect information on the effect of work stress on health was explained. The post-survey interview questions were used to gain in-depth insight into the findings of the respective objective.

CHAPTER 5: RISK FACTORS FOR MENTAL ILL-HEALTH AMONG SUPERVISORS AND TRADESMEN[12]

5.1 Introduction

There is information on risk factors for mental ill-health among construction professionals in Australia, The Netherlands, and the United Kingdom (Love et al., 2010, Sunindijo and Kamardeen, 2017, Boschman et al., 2013, Sutherland and Davidson, 1993). However, the ability of a stressor to cause mental ill-health and suicidality varies from country to country (Li et al., 2017). Explicitly, the one-size-fits-all interventions do not apply to mental health problems as they are highly context-specific (Rebar and Taylor, 2017). Most research on risk factors of mental ill-health and the prevalence of mental ill-health in the construction industry focused on developed countries while developing countries have not been adequately investigated. Information from a lower-middle-income country like Nigeria, the most populous country in Africa is expedient because it will influence decision-making beneficial to individuals and organizations in similar contexts as well as other economies.

Overall, there is a need for more research into specific factors that can increase the risk of mental ill-health within the industry, which could assist in building robust interventions in the

[12] This chapter is largely based on the articles below produced by the author of the thesis during the PhD study:
Nwaogu, J. M., Chan, A. P. C. and Sunindijo, R. Y. Under Review-b. Prevalence and Risk Factors of Mental Ill-health and Suicidal Ideation in the Construction Industry of Nigeria. *Journal of Civil Engineering and Management*. SCEM-2021-0135.
Nwaogu, J. M., Chan, A. P. C. and Darko, A. Under Review-a. Risk Factors Influencing Mental Ill-health and Suicide Ideation among Construction Tradesmen in Nigeria. *International Journal of Building and Pathology*. IJBPA-11-2020-0098.R1.

workplace (Chan et al., 2020). Information on work and non-work stressors will improve the development of sustainable intervention strategies for mental health among construction supervisors and tradesmen. Thus, there is a dearth of research regarding the prevalence of mental ill-health and suicide ideation of construction supervisors and tradesmen in the construction industry of Nigeria. Therefore, to fill the gap, this study aimed to investigate the mental health of supervisors and tradesmen in Nigeria with a view to providing information that will assist in effective interventions within the construction industry. To achieve this aim, the objectives of this study were to determine the: (1) prevalence of common mental ill-health, (2) work and non-work modifiable risk factors of mental ill-health among construction supervisors and tradesmen in Nigeria. The objectives were further achieved by testing the hypothesis stated in section 2.6.2.4.

This would assist in determining the cluster of modifiable risk factors and appropriate interventions required to be deployed. Given that risk factors do not emerge in isolation but rather clustered together (Chan et al., 2020), interventions aimed at promoting the personnel's mental health should be directed toward the clusters of risk factors. This study will assist in policy-making geared towards site personnel. The findings will assist in developing interventions appropriate within the construction industry in Nigeria and other countries.

5.2 Research Design

As described in Section 4.6, the positivism and interpretivism philosophies were used to guide the study. Thus, quantitative methodology and post-survey interviews were adopted. The questionnaire survey was used to solicit information from construction site supervisors and tradesmen engaged in construction projects based on the methodology. The post-survey interview was used to assess the findings and gain more insights into them. The research instruments include the PHQ-9, GAD-2, and stressors' questionnaire.

5.2.1 Data collection

5.2.1.1 Data collection among supervisors

The questionnaires were delivered by hand to purposively selected construction supervisors on 65 construction sites in Abuja and Lagos. An electronic version of the questionnaire was sent to construction supervisors who indicated a preference for it. In total, 550 copies of the questionnaires were administered to supervisors.

5.2.1.2 Data collection among tradesmen

The questionnaires were delivered by hand to purposively recruited construction tradesmen on 65 construction sites in Abuja and Lagos. In total, 453 copies of the questionnaires were administered to tradesmen. Finally, a post-survey interview was conducted with eight tradesmen who partook in the survey and indicated a keen interest in the research result. The post-survey interview was based on the result obtained from the survey.

5.2.2 Data analysis

The data were analyzed using descriptive statistics (mean score, frequency, and chi-square) and logistic regression (univariate) in SPSS 20.0. The univariate logistic regression analysis was used to determine the association between the stressors and mental ill-health symptoms. In analyzing mental ill-health symptoms, the respondents were classified into two groups as described in Section 4.6.4.6.

5.3 Results for Supervisors

5.3.1 Profile of the supervisors

As shown in Table 5.1, out of the 550 questionnaires distributed, 174 duly valid responses were retrieved, yielding a response rate of 32%. All the respondents were affiliated to a professional body, out of which 128 (73.7%) had over six years of work experience. The majority, 158 (90.8%) personnel, were males, while 16 (9.2%) were females. The representation of the construction personnel is as follows: architects (1.1%), quantity surveyors (2.9%), civil engineers (42.5%), and building engineers (53.4%); engaged as project managers, site engineers/supervisors, and their assistants.

5.3.2 Mental ill-health symptoms among the supervisors

As detailed in Table 5.1, the mean PHQ-9 score was 5.33 ± 3.80, and the mean GAD-2 score was 1.20 ± 1.39. More than half (54.6%) of the supervisors had depression. Out of those with depression, 16 (9.2%) had suicidal ideation, with item response indicating that 13 supervisors (7.4%) had suicidal ideation for several days in two weeks, while three (1.7%) experienced it for more than half the days. The prevalence rates of mild, moderate, and moderately severe depression were 65 (37.4%), 27 (15.5%), and 3 (1.7%), respectively. Using GAD-2, 149 supervisors (85.6%) had no anxiety, and 25 (14.4%) had mild-moderate anxiety. Pearson's correlation coefficient between the PHQ-9 and GAD-2 scores was 0.244 (p-value = 0.001). From chi-square analysis shown in Table 5.2, suicidal ideation was also statistically associated with depression ($\chi^2 = 10.90$, $p = 0.001$) and anxiety ($\chi^2 = 18.18$, $p = 0.000$).

Table 5. 1: Demographic and mental ill-health characteristics of the construction supervisors

Variable	Categories	Descriptive analysis			
		Frequency (%)	Mean (SD)	Pearson Correlation	p-value (2-tailed)
Demographics characteristics					
Sex	Male	158 (90.8)			
	Female	16 (9.2)			
Type of firm	Micro	37 (21.3)			
	Small	59 (33.9)			
	Medium	46 (26.4)			
	Large	32 (18.4)			
Years of Experience					
	1-5 years	46 (26.4)			
	6-10 years	66 (37.9)			
	11-15 years	41 (23.6)			
	16-20 years	10 (5.7)			
	21-25 years	4 (2.3)			
	over 25 years	7 (4.0)			
Position	Project Manager	62 (35.6)			
	Site Engineer / Supervisor	73 (41.9)			
	Asst. Site Engineer / Supervisor	39 (22.4)			
Education	HND	43 (24.7)			
	PGD	19 (10.9)			
	BSc. / B.Tech.	67 (38.5)			
	MSc. / M. Tech.	45 (25.9)			
Professional Affiliation					
	NIOB	93 (53.4)			
	NICE	74 (42.5)			
	NIQS	5 (2.9)			
	NIA	2 (1.1)			
Mental ill-health symptoms					
Depression			5.33 (3.80)		
	None (0-4)	79 (45.4)			
	Mild (5-9)	65 (37.4)			
	Moderate (10-14)	27 (15.5)			
	Moderately severe (15-19)	3 (1.7)			
	Suicidal ideation	16 (9.2)			
Anxiety			1.20 (1.39)		
	None	149 (85.6)			
	Mild-moderate	25 (14.4)			
Depression-Anxiety				0.244^{**}	0.001

Note: HND- Higher National Diploma; PGD- Post-Graduate Diploma; BSc./B.Tech- Bachelor's degree; MSc. / M.Tech – Master's degree; SD- Standard Deviation; ** Significant at the 0.01 level (2-tailed).

5.3.2.1 Demographic variables associated with depression and anxiety

The Chi-square test for differences in groups revealed that there was no statistically significant relationship between the demographic characteristics (i.e., gender, organization structure, and education) and depression. As detailed in Table 5.2, among the demographic characteristics, organization structure had a statistically significant relationship with anxiety (χ^2 = 7.94, df = 6, p = 0.02), with a significant difference between the type of organization structure. A posthoc test for the significant difference using Bonferroni correction revealed that, as regards anxiety, supervisors who worked in matrix structure firms were significantly different (χ^2 = 7.80, df = 1, p = 0.02) compared to those in pyramidal and flat structure. This result indicates that supervisors who worked in matrix structure firms were more anxious than those in pyramidal and flat structures (χ^2 = 7.80, df = 1, p = 0.00).

5.3.3 Mean scores of the sources of stress to construction supervisors

Approximately 66% of the sources of stress had mean values above the 2.00 cut-off for a 4-point Likert scale. As shown in Table 5.3, the top five stressors are work overload (2.59), increased work speed (2.58), low income (financial insecurity) (2.57), job insecurity (2.51), and poor working conditions (2.50). The Kruskal Wallis test result revealed a statistically significant difference in the responses of the supervisors’ groups regarding two stressors, namely: low income causing financial insecurity (p = 0.026) and criticisms from boss and colleagues (p = 0.008).

Table 5. 2: Frequency distribution of supervisors by mental health status and demographic variables

	Depression	No Depression	χ^2 / F	p-value	Suicidal ideation	No Suicidal Ideation	Anxiety	No Anxiety	χ^2 / F	p-value
Personnel (n = 174)	95 (54.6)	79 (45.4)			16 (16.8)	79 (83.2)	25 (14.4)	149 (85.6)		
Gender			2.08	0.19					1.62	0.25^F
Male (n = 158)	89 (56.3)	69 (43.7)			14 (15.7)	75 (84.3)	21 (13.3)	137 (86.7)		
Female (n = 16)	6 (37.5)	10 (62.5)			2 (33.3)	4 (66.7)	4 (25.0)	12 (75.0)		
Years of experience										
1-5yrs (n = 46)	24 (52.2)	22 (47.8)	2.54^F	0.79	4 (16.7)	20 (83.3)	4 (8.7)	42 (91.3)	7.03^F	0.16
6-10yrs (n = 66)	38 (57.6)	28 (41.8)			6 (15.48	32 (84.2)	11 (16.7)	55 (83.3)		
11-15yrs (n = 41)	24 (58.5)	17 (41.5)			3 (12.5)	21 (87.5)	7 (17.1)	34 (82.9)		
16-20yrs (n =10)	5 (50.0)	5 (50.0)			-	5 (100)	-	10 (100)		
21-25yrs (n = 4)	1 (25.0)	3 (75.0)			-	4 (100)	-	4 (100.0)		
> 25yrs (n = 7)	3 (42.9)	4 (57.1)			3 (100.0)	-	3 (42.9)	4 (57.1)		
Firm size			1.73	0.64					2.03	0.57
Micro (n = 37)	21 (56.8)	16 (43.2)			5 (23.8)	16 (76.2)	7 (18.9)	30 (81.1)		
Small (n = 59)	32 (54.2)	27 (45.8)			2 (6.3)	30 (93.8)	6 (10.2)	53 (89.8)		
Medium (n = 46)	22 (47.8)	24 (52.2)			4 (18.2)	18 (81.8)	6 (13.0)	40 (87.0)		
Large (n = 32)	20 (62.5)	12 (37.5)			5 (25.0)	15 (75.0)	6 (18.8)	26 (81.2)		
Organization structure			1.97	0.39					**7.94**	**0.02**
Flat (n= 75)	43 (57.3)	32 (42.7)			8 (18.6)	35 (81.4)	8 (10.7)	67 (89.3)		
Pyramid (n = 79)	39 (49.4)	40 (50.6)			4 (10.3)	35 (89.7)	10 (12.7)	69 (87.3)		
Matrix (n =20)	13 (65.0)	7 (35.0)			4 (30.8)	9 (69.2)	7 (35.0)	13 (65.0)		
Education			3.13	0.38					5.37	0.15
HND (n = 43)	23 (53.5)	20 (46.5)			5 (21.7)	19 (82.6)	9 (20.9)	34 (79.1)		
PGD (n = 19)	8 (42.1)	11 (57.9)			4 (50.0)	4 (50.0)	3 (15.8)	16 (84.2)		
BSc/Tech (n = 67)	35 (52.2)	32 (47.8)			5 (14.3)	30 (85.7)	11 (16.4)	56 (83.6)		
MSc/Tech (n = 45)	29 (64.4)	16 (35.6)			2 (6.9)	27 (93.1)	2 (4.4)	43 (95.6)		
Suicidal Ideation			**10.90**	**0.00**					**18.18**	**0.00**

Note: p = p-value; bold values are significantly different at 0.05; $\chi 2$ = Chi-square; F = Fisher Exact test and score; HND = Higher National Diploma; PGD = Post-Graduate Diploma; BSc/Tech = Bachelor degree; MSc/Tech = Master degree.

Table 5. 3: Perceived sources of stress among the supervisors.

Code	**Measures**	**All Gender**			**Male**			**Female**			**p-value**
		Mean	SD	Rank	Mean	SD	Rank	Mean	SD	Rank	
CS04	Work overload	2.59	0.98	1	2.60	0.98	2	2.44	1.03	7	0.493
CS05	Increased work speed	2.58	0.85	2	2.60	0.98	3	2.75	0.68	1	0.372
CS27	Low income (financial insecurity)	**2.57**	**0.94**	**3**	**2.62**	**0.91**	**1**	**2.06**	**1.18**	**17**	**0.026***
CS11	Job insecurity (fear and uncertainty about the work)	2.51	1.09	4	2.53	1.08	4	2.25	1.13	13	0.311
CS10	Poor working conditions (such as no leave, or no housing allowances)	2.50	1.10	5	2.52	1.08	5	2.31	1.30	10	0.426
CS13	Fatigue resulting from work causing poor sleep and recovery	2.41	0.98	6	2.43	0.99	6	2.25	0.93	12	0.473
CS03	Hours worked per day (over 60hrs per week)	2.34	1.03	7	2.31	1.04	11	2.63	0.81	2	0.165
CS12	Strict adherence to the time or schedule (you cannot decide the timing for executing a task)	2.33	1.01	8	2.33	1.03	9	2.37	0.81	9	0.753
CS37	Lack of opportunity for promotion	2.33	1.05	9	2.35	1.06	8	2.13	0.96	15	0.422
CS36	Lack of opportunity for career development while you still work on a particular job	2.32	1.05	10	2.32	1.03	10	2.31	1.20	11	0.905
CS26	Work-home/life imbalance	2.31	1.11	11	2.36	1.12	7	1.81	0.98	30	0.056
CS06	Little opportunity/ability to participate in decision making	2.29	0.95	12	2.28	0.96	12	2.38	0.96	8	0.692
CS02	Nature of work causing increased mental demand	2.24	0.97	13	2.21	0.97	17	2.50	0.89	4	0.240
CS07	Little social support from colleagues/immediate supervisors	2.23	0.88	14	2.21	0.87	16	2.44	0.89	6	0.249
CS35	Lack of subsidies for family travel fees in the case of a transfer	2.23	1.09	15	2.25	1.09	14	2.06	1.12	16	0.084
CS08	Little relationship with colleagues/co-workers	2.21	0.97	16	2.17	0.97	19	2.56	0.96	3	0.129
CS34	Lack of a medical plan for employees	2.21	1.05	17	2.25	1.05	13	1.81	0.98	28	0.084
CS14	Criticisms from superiors	**2.18**	**0.98**	**18**	**2.24**	**0.98**	**15**	**1.56**	**0.73**	**36**	**0.008***
CS15	Lack of feedback mechanism in place	2.17	0.94	19	2.19	0.95	18	1.94	0.93	26	0.290
CS18	Little task authority	2.13	0.93	20	2.09	0.91	22	2.44	1.03	5	0.210
CS16	Low socio-economic status (your position relative to your peers)	2.13	0.98	21	2.14	0.98	20	2.06	0.93	18	0.790
CS33	Under promotion	2.10	1.02	22	2.12	1.02	21	1.94	0.99	23	0.503
CS38	Lack of team or departmental or company social get-togethers	2.09	0.93	23	2.09	0.92	23	2.00	1.10	19	0.510
CS28	Salaries not paid on time	2.04	1.07	24	2.04	1.05	24	2.00	1.32	21	0.600
CS29	Unsatisfactory living condition	2.02	0.87	25	2.03	0.88	25	1.94	0.85	24	0.708
CS22	Poor physical working condition	1.99	0.95	26	2.03	0.95	26	1.69	0.95	32	0.141
CS01	Physical illness arising from work pressure	1.95	0.70	27	1.92	0.70	27	2.25	0.58	14	0.053
CS19	Fear of failure	1.88	0.94	28	1.87	0.94	28	1.94	0.99	25	0.833
CS21	Musculoskeletal pain and injuries	1.83	0.87	29	1.85	0.86	29	1.69	0.95	32	0.360
CS32	Poor family connection / relationships	1.79	0.93	30	1.77	0.93	31	2.00	0.89	20	0.208
CS20	Interpersonal conflict at work	1.78	0.81	31	1.80	0.81	30	1.63	0.81	34	0.375
CS09	Occupational injury/hazards	1.75	0.81	32	1.72	0.79	33	2.00	1.03	22	0.330
CS30	Past traumatic experiences (death of a relative or bad happening)	1.73	0.93	33	1.72	0.92	34	1.88	1.02	27	0.578
CS24	Workplace harassment	1.69	0.76	34	1.72	0.75	32	1.44	0.81	38	0.087
CS23	Lack of respect from subordinates	1.67	0.76	35	1.69	0.75	35	1.50	0.73	36	0.161
CS31	Marital relationship or challenges	1.66	0.89	36	1.64	0.90	37	1.81	0.75	29	0.194
CS17	Over-promotion- the job task is more than your experience with no mentoring	1.65	0.82	37	1.64	0.77	36	1.75	1.24	31	0.607
CS25	Workplace bullying	1.59	0.78	38	1.58	0.77	38	1.62	0.96	35	0.853

Note: SD- Standard Deviation; Bold values are significantly different at 0.05 (2-tailed) using Kruskal Wallis test; 1 = never; 2 = very little; 3 = moderately; 4 = very great.

Table 5. 4: Univariate logistic regression of stressors associated with poor mental health among supervisors.

Code	Variables	Depression			Anxiety		
		p-value	cOR	95% CI	p-value	cOR	95% CI
D	Organization Structure				0.029		
	Flat structure*				-	-	-
	Pyramidal Structure				0.701	1.214	(0.45, 3.26)
	Matrix Structure				**0.012**	**4.510**	**(1.39, 14.61)**
CS01	Physical illness arising from work pressure	**0.001**	**3.27**	**(1.60, 6.67)**	0.231	1.99	(0.65, 6.16)
CS02	Nature of work causing increased mental demand	**0.000**	**3.94**	**(1.91, 8.12)**	0.089	2.98	(0.85, 10.46)
CS03	Hours worked per day	0.383	1.36	(0.68, 2.71)	0.681	0.82	(0.32, 2.12)
CS04	Workload	**0.002**	**4.26**	**(1.70, 10.71**	0.998	33.00	(10.01, 45.13)
CS05	Increased work speed	**0.009**	**3.77**	**(1.40, 10.16)**	0.191	3.94	(0.51, 30.68)
CS06	Little opportunity to participate in decision making	**0.000**	**4.93**	**(2.22, 10.96)**	0.080	3.80	(0.86, 16.89)
CS07	Little social support from colleagues and supervisors	**0.000**	**4.96**	**(2.17, 11.37)**	0.255	2.09	(0.59, 7.40)
CS08	Little relationship with colleagues and supervisors	**0.000**	**4.03**	**(1.98, 8.19)**	0.064	3.28	(0.93, 11.49)
CS09	Occupational injury/hazard	**0.000**	**3.36**	**(0.80, 6.27)**	**0.029**	**2.96**	**(1.12, 7.83)**
CS10	Poor working conditions (e.g., no leave or housing allowance)	**0.015**	**2.53**	**(1.20, 5.31)**	0.423	0.68	(0.26, 1.76)
CS11	Job insecurity	**0.002**	**3.39**	**(1.58, 7.30)**	0.088	3.66	(0.82, 16.30)
CS12	Strict adherence to time or schedule	**0.002**	**3.18**	**(1.53, 6.60)**	0.986	1.01	(0.37, 2.72)
CS13	Fatigue resulting from work causing poor sleep and recovery	**0.003**	**3.49**	**(1.55, 7.89)**	0.070	6.56	(0.86,50.39)
CS14	Criticisms from superiors	0.052	1.93	(0.99, 3.73)	0.530	1.37	(0.51, 3.66)
CS15	Lack of feedback mechanism in place	0.569	1.22	(0.62, 2.38)	0.904	0.94	(0.37, 2.43)
CS16	Low socio-economic status	**0.001**	**3.07**	**(1.55, 6.06)**	0.274	1.79	(0.63, 5.05)
CS17	Over promotion	**0.039**	**1.89**	**(1.03, 3.48)**	0.256	0.60	(0.25, 1.45)
CS18	Little task authority	**0.009**	**2.40**	**(1.24, 4.65)**	0.099	2.57	(0.84, 7.90)
CS19	Fear of failure at the job	**0.004**	**2.48**	**(1.34, 4.58)**	0.183	0.56	(0.24, 1.32)
CS20	Interpersonal conflict at work	0.093	1.68	(0.92, 3.08)	0.972	0.99	(0.42, 2.31)
CS21	Musculoskeletal pain and injuries	**0.004**	**2.47**	**(1.33, 4.57)**	0.477	1.38	(0.57, 3.31)
CS22	Poor physical working condition	0.523	1.22	(0.66, 2.26)	0.510	1.35	(0.55, 3.34)
CS23	Lack of respect from subordinates	0.240	1.43	(0.79, 2.61)	0.084	2.21	(0.90, 5.44
CS24	Workplace harassment	0.608	0.86	(0.47, 1.56)	0.406	1.44	(0.61, 3.41)
CS25	Workplace bullying	0.098	1.00	(0.55, 1.84)	0.334	1.52	(0.65, 3.56)
CS26	Work-home/life imbalance	**0.000**	**3.40**	**(1.73, 6.71)**	0.773	1.15	(0.45, 2.94)
CS27	Low income causing financial insecurity	0.068	2.48	(0.94, 6.55)	0.557	1.58	(0.34, 7.27)
CS28	Salaries not paid on time	0.924	1.03	(0.56, 1.89)	0.774	0.88	(0.38, 2.07)
CS29	Unsatisfactory living condition at home	**0.000**	**3.84**	**(1.93, 7.63)**	0.450	1.46	(0.55, 3.89)
CS30	Past traumatic experience	0.945	0.98	(0.54, 1.78)	**0.024**	**2.82**	**(1.15, 6.95)**
CS31	Marital relationship and challenges	**0.006**	**2.40**	**(1.29, 4.47)**	0.163	1.84	(0.78, 4.32)
CS32	Poor family connection or relationships	**0.012**	**2.19**	**(1.19, 4.02)**	**0.014**	**3.35**	**(1.28, 8.96)**
CS33	Under promotion	**0.000**	**3.61**	**(1.88, 6.96)**	0.216	1.85	(0.70, 4.92)
CS34	Lack of a medical plan for employees	**0.000**	**4.04**	**(2.04, 8.03)**	0.204	1.96	(0.69, 5.53)
CS35	Lack of subsidies for family travel fees in the case of a transfer	**0.002**	**2.83**	**(1.46, 5.51)**	0.910	0.95	(0.38, 2.36)
CS36	Lack of opportunity for career development	0.053	1.94	(0.99, 3.78)	0.349	0.65	(0.27, 1.59)
CS37	Lack of opportunity for promotion	0.116	1.75	(0.87, 3.50)	0.281	1.86	(0.60, 5.76)
CS38	Lack of team or departmental or company social get-togethers	0.101	1.72	(0.90, 3.27)	0.379	1.55	(0.583, 4.132)

Note: cOR- Crude odds ratio; CI- Confidence interval; D- Demographic Character; CS- Cause of stress; * Reference group; To conserve space, only the likelihood of occurrence based on each stressor is outlined in the Table.

5.3.4 Univariate logistic regression analysis among supervisors

Table 5.4 shows the results of the logistic regression model for depression and anxiety. On the univariate logistic regression, depression was found to be significantly associated with 24 of 38 stressors, including physical illness (cOR = 3.27, 95% CI: 1.60-6.67), nature of work (cOR = 3.94, 95% CI: 1.91-8.12), workload (cOR = 4.26, 95% CI: 1.70-10.71), increased work speed (cOR = 3.767, 95% CI: 1.40-10.16), little opportunity to participate in decision making (cOR = 4.93, 95% CI: 2.22-10.96), and job insecurity (cOR = 3.39, 95% CI: 1.58-7.30). Anxiety was found to be significantly associated with occupational injury/hazard (cOR = 2.96, 95% CI: 1.12-7.83), past traumatic experience (cOR = 2.82, 95% CI: 1.15-6.95), poor family connection (cOR = 3.35, 95% CI: 1.28-8.96) and organization structure (cOR = 4.51, 95% CI: 1.39-14.61). Thus, hypothesis $H1_1$ was supported.

Finally, confirming the results of the Chi-square test (see Table 2), univariate logistic regression revealed that depression (cOR = 14.268, 95% CI: 1.84-110.596, p = 0.011) and anxiety (cOR = 7.89, 95% CI: 2.637-23.60, p = 0.000) were significant risk factors for suicidal ideation. Based on the theoretical background, the classification by Chan et al. (2020) and Cheung and Yip (2015), a conceptual framework showing the relationship between the demographic characteristics, risk factors, and mental health conditions was developed (Figure 5.1). Figure 5.1 further shows that both work and non-work-related stressors are associated with poor mental health symptoms.

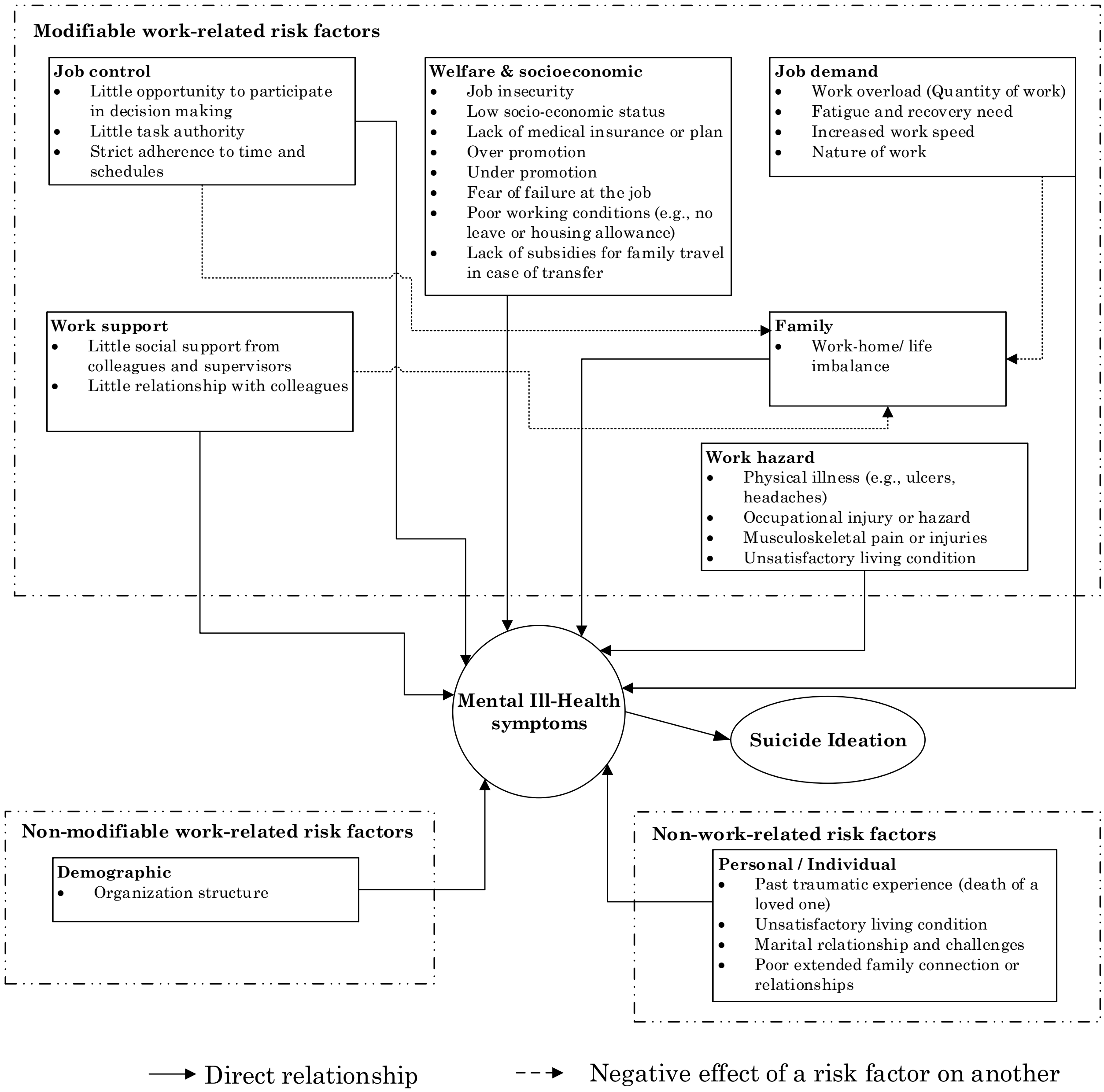

Figure 5. 1. A framework for mental ill-health among supervisors

5.4 Results for Tradesmen

5.4.1 Profile of the tradesmen

Out of the 453 questionnaires delivered to the tradesmen through their site supervisors, only a total of 110 duly filled questionnaires were retrieved, yielding a response rate of 24.3%, as shown in Table 5.5. All the tradesmen have more than ten years of working experience in their trade and have at least a secondary school leaving certificate. This implies that they are fit to provide reliable information for the study. All the tradesmen are males, pointing to the masculine nature of the industry. The trade representation of the respondents includes iron bending, masonry, and carpentry.

5.4.2 Mental ill-health symptoms among the tradesmen

The mean PHQ-9 score was 1.93±0.71, and the mean GAD-2 score was 1.36±0.48, as shown in Table 5.5. Out of the 110 tradesmen, about three-quarters of them, 82 (74.5%) had depression. Out of those with depression, 16 (14.6%) had suicidal ideation. The prevalence rate of mild depression (PHQ-9 score 5–9) among the tradesmen was 63 (57.3%), 14 (12.7%) for moderate depression (PHQ-9 score 10–14), and 5 (4.5%) for moderately severe depression (PHQ-9 score 15-19). While there is a 74.5% prevalence rate of depressive symptoms (PHQ≥5), the prevalence of major depression (PHQ≥10) is 17.2% and 57.3% for minor depression (PHQ 5-9) among the tradesmen. Item response showed that 6 (5.5%) of the tradesmen had suicidal ideation for several days in two weeks and 10 (9.1%) for more than half the days. Using GAD2, the prevalence rate of none-minimal anxiety (GAD-2 score 0–2) was 70 (63.6%), and 40 (36.4%) for anxiety (GAD-2 score ≥ 3). This study did not find any correlation between the PHQ-9 score and the GAD-2 score. There existed a correlation coefficient between the GAD-2 score and suicide ideation ($\alpha = 0.331$, $p = 0.000$).

Table 5. 5: Demographic and mental ill-health characteristics of the tradesmen

Variable	Categories	Descriptive analysis			
		Frequency (%)	Mean (SD)	Pearson Correlation	p-value (2-tailed)
Demographics characteristics					
Sex	Male	110 (100.0)			
Type of firm	Micro	6 (5.5)			
	Small	30 (27.3)			
	Medium	64 (58.2)			
	Large	10 (9.1)			
Organization structure					
	Flat	38 (34.5)			
	Pyramid	54 (49.1)			
	Matrix	18 (16.4)			
Years of Experience					
	11-15 years	52 (47.3)			
	16-20 years	38 (34.5)			
	21-25 years	6 (5.5)			
	over 25 years	14 (12.7)			
Trade	Iron Bender	34 (30.9)			
	Mason	30 (27.3)			
	Carpenter	20 (18.2)			
	POP decorator/painter	10 (9.1)			
	Concreter	8 (7.3)			
	Plumber	6 (5.5)			
	Tiler	2 (1.8)			
Education	Secondary School Certificate	12 (10.9)			
	Trade Test	52 (47.3)			
	NVQ	28 (25.5)			
	OND	18 (16.4)			
Mental ill-health symptoms					
Depression			1.93 (0.71)		
	None-Minimal (0-4)	28 (25.5)			
	Mild (5-9)	63 (57.3)			
	Moderate (10-14)	14 (12.7)			
	Moderately severe (15-19)	5 (4.5)			
	Suicide ideation	16 (14.6)			
Suicide ideation	Several days	6 (5.5)			
	More than half the days	10 (9.1)			
Anxiety			1.36 (0.48)		
	None-minimal (0-2)	70 (63.6)			
	Mild-moderate (≥3)	40 (36.4)			
Anxiety-Suicide ideation				0.331	0.0004

5.4.2.1 Demographic variables associated with depression and anxiety among tradesmen

The Chi-square (or Fisher) test for differences in groups revealed that there was a statistically significant relationship between the demographic characteristics (years of experience, firm size, organization structure, and education), depression, and anxiety. As detailed in Table 5.6, among the demographic characteristics, organization structure had a statistically significant relationship with depression (Fisher's exact test = 20.87, p = 0.000); with a significant difference between the organization structure group (pyramid structure, p = 0.000; matrix, p = 0.007). On the one hand, tradesmen with work experience less than 20 years (p = 0.000) were more likely to have depressive symptoms than others. On the other hand, younger tradesmen with less than 15 years of work experience (p = 0.001) and older tradesmen with more than 25 years (p = 0.002) were likely to have anxiety symptoms than others. With respect to anxiety symptoms, there existed a significant difference between the type of firm size, as tradesmen who work in micro firms (p = 0.001) were likely to be anxious than others.

Table 5. 6: Frequency distribution of tradesmen by mental health status and demographic variables

	Depression	No Depression	Test				Test	
	Frequency (%)	Frequency (%)	χ^2 or Fisher's	p-value	Anxiety	No Anxiety	χ^2 or /Fisher's	p-value
Personnel (n = 110)	82 (74.5)	28 (25.5)			40 (36.4)	70 (63.6)		
Years of experience			**24.76***	**0.000**			**22.49***	**0.000**
Trades			**20.92***	**0.001**			8.548**	0.177
Firm size			**8.240***	**0.031**			**12.16***	**0.005**
Organization structure			**20.87****	**0.000**			0.89**	0.645
Education			5.542*	0.133			3.595*	0.310

Note: Bold values are significantly different at <0.05; χ^2 = Chi-square test; * Fisher's Exact Test; ** Chi-square Test

5.4.3 Mean scores of sources of stress to the tradesmen

As shown in Table 5.7, about three-quarters (74.3%) of the sources of stress had a minimum mean value of 2.00 on a 4-point Likert scale. The top seven sources of work stress among tradesmen include: increased work speed, job insecurity, hours worked per day, work overload, little opportunity/ability to participate in decision making, physical illness, and lack of opportunity for career development ranked with mean scores of 2.71, 2.53 2.47, 2.42, 2.42, 2.40, 2.38 respectively.

Table 5. 7: Perceived sources of stress among the tradesmen

Code	Sources of stress	Mean	SD	Rank
CS04	Increased work speed	2.71	1.07	1
CS09	Job insecurity (fear or uncertainty about the work)	2.53	1.18	2
CS02	Hours worked per day	2.47	1.05	3
CS03	Work overload (too much quantity of work)	2.42	1.18	4
CS05	Little opportunity/ability to participate in decision making	2.42	1.26	5
CS01	Physical illness caused by day work (e.g., headache, ulcers)	2.40	1.16	6
CS31	Lack of opportunity for career development while you still work on a particular job	2.38	1.11	7
CS10	Fatigue resulting from work causing poor sleep and recovery	2.36	1.02	8
CS18	Musculoskeletal pain and injuries	2.36	1.11	9
CS24	Low income (financial insecurity)	2.35	1.02	10
CS32	Lack of opportunity for promotion	2.29	1.07	11
CS30	Lack of medical subsidies/insurance	2.29	1.17	12
CS06	Little support from colleagues / immediate supervisors	2.27	1.04	13
CS12	Lack of feedback mechanism in place	2.25	1.04	14
CS25	Salaries not paid on time	2.22	1.07	15
CS19	Poor physical working condition	2.22	1.07	16
CS08	Occupational injury or hazards	2.16	1.03	17
CS26	Unsatisfactory living condition at home	2.15	0.95	18
CS23	Work-home/life imbalance	2.13	0.88	19
CS07	Little relationship with colleagues/co-workers	2.13	1.16	20
CS22	Workplace bullying	2.11	0.99	21
CS27	Past traumatic experiences (death of a relative or accident or bad happening)	2.11	1.26	22
CS13	Low socioeconomic status (your position relative to your peers)	2.09	0.95	23
CS15	Little task authority	2.09	0.97	24
CS28	Marital relationship or challenges	2.05	1.08	25
CS33	Lack of team or departmental or company social get-togethers	2.00	1.15	26
CS11	Criticisms from boss and colleagues	1.95	0.89	27
CS14	Over-promotion- the job task is more than your experience with no mentoring	1.93	1.14	28
CS21	Workplace harassment	1.89	0.98	29
CS29	Poor family connection / relationships	1.76	0.82	30
CS16	Fear of failure on the job	1.75	1.04	31
CS20	Lack of respect from subordinates	1.60	0.76	32
CS17	Interpersonal conflict at work	1.60	0.99	33

Note: SD- Standard Deviation; 1 = never; 2 = very little; 3 = moderately; 4 = very great.

5.4.4 Association between stressors and mental health among tradesmen

Table 5.8 shows the results of the logistic regression analysis for mental ill-health symptoms. On the univariate logistic regression, twenty-seven (27) of 33 stressors were associated with poor mental health. The stressors that were significantly associated with both depression and anxiety include work overload, little relationship with colleagues and supervisors, occupational injury or hazard, job insecurity, excessive alcohol consumption, lack of respect from subordinates, unsatisfactory living condition at home, past traumatic experience, marital relationship and challenges, and poor family connection or relationships.

Depression was found to be significantly associated with twenty-three (23) of 33 stressors. The stressors associated with depression includes: physical illness (OR = 3.09, 95% CI: 1.22-7.81), hours worked per day (OR = 7.78, 95% CI: 2.96-20.46), increased work speed (OR = 2.88, 95% CI: 1.00-8.26), little opportunity to participate in decision making (OR = 7.75), over-promotion (OR = 8.47), litte task authority (OR = 3.64), low income causing financial insecurity (OR = 4.38), salaries not paid on time (OR = 4.74), fear of failure (OR = 0.39), and workplace harassment (OR = 4.33). This indicates that the stressors were 3.1 times, 7.8 times, 2.9 times, 7.8 times, 8.5 times, 3.6 times, 4.4 times, 4.7 times, 0.4 times, and 4.3 times respectively, more likely to cause depression among tradesmen. Thus, hypothesis $H1_1$ was supported.

Anxiety was found to be significantly associated with eighteen (18) stressors. The stressors associated with only anxiety includes: work overload (OR = 5.32, 95% CI: 1.70-16.65), low socioeconomic status (OR = 7.58), interpersonal conflict at work (OR = 2.89), substance abuse (OR = 3.22), work-home/life imbalance (OR = 4.13), fatigue (OR = 4.70), musculoskeletal pain and injuries (OR = 3.35) and lack of team or departmental or company social get-togethers (OR =

5.08). This indicates that the stressors were 5.3 times, 7.6 times, 2.9 times, 3.2 times, 4.1 times, 4.7 times, 3.4 times, and 5.1 times respectively, more likely to cause anxiety among the study participants. Anxiety (OR = 7.07, 95% CI: 2.10-23.83, p = 0.002) was a significant risk factor for suicide ideation. This indicates that anxiety is 7.1 times more likely to cause suicide ideation among the tradesmen. The relationship between the demographic characteristics, stressors, and mental health conditions is represented in Figure 5.2.

Table 5. 8: Univariate logistic regression of stressors associated with poor mental health among tradesmen.

Code	Variables	Depression			Anxiety		
		p-value	OR	95% CI	p-value	OR	95% CI
CS01	Physical illness caused by day work	**0.017**	**3.09**	**(1.22, 7.81)**	0.998	-	-
CS02	Hours worked per day	**0.000**	**7.78**	**(2.96, 20.46)**	0.062	2.60	(0.95, 7.09)
CS03	Workload	**0.035**	**2.67**	**(1.07, 6.65)**	**0.004**	**5.32**	**(1.70, 16.65)**
CS04	Increased work speed	**0.049**	**2.88**	**(1.00, 8.26)**	0.181	2.25	(0.69, 7.38)
CS05	Little opportunity to participate in decision making	**0.000**	**7.75**	**(2.96, 20.29)**	0.064	2.25	(0.95, 5.31)
CS06	Little support from colleagues and supervisors	0.944	0.97	(0.38, 2.49)	0.304	0.64	(0.28, 1.49)
CS07	Little relationship with colleagues and supervisors	**0.002**	**4.33**	**(1.70, 11.04)**	**0.000**	**9.60**	**(3.55, 25.92)**
CS08	Occupational injury or hazard	**0.000**	**5.50**	**(2.18, 13.89)**	**0.002**	**6.00**	**(1.92, 18.73)**
CS09	Job insecurity	**0.000**	**5.50**	**(2.18, 13.89)**	**0.002**	**6.00**	**(1.92, 18.73)**
CS10	Fatigue resulting from work causing poor sleep and recovery	0.661	1.24	(0.47, 3.25)	**0.008**	**4.70**	**(1.50, 14.75)**
CS11	Criticisms from superiors	0.060	2.31	(0.97, 5.53)	0.274	1.56	(0.70, 3.49)
CS12	Lack of feedback mechanism in place	0.067	2.32	(0.94, 5.73)	0.116	2.09	(0.83, 5.23)
CS13	Low socioeconomic status	0.189	1.81	(0.75, 4.40)	**0.000**	**7.58**	**(2.44, 23.58)**
CS14	Over promotion	**0.000**	**8.47**	**(2.69, 26.65)**	0.665	1.187	(0.55, 2.59)
CS15	Little task authority	**0.005**	**3.64**	**(1.49, 8.89)**	0.018	3.00	(1.21, 7.44)
CS16	Fear of failure at the job	**0.035**	**0.39**	**(0.16, 0.93)**	0.108	1.92	(0.87, 4.23)
CS17	Interpersonal conflict at work	0.997	-	-	**0.011**	**2.89**	**(1.27, 6.56)**
CS18	Musculoskeletal pain and injuries	0.067	2.33	(0.94, 5.73)	**0.017**	**3.35**	**(1.24, 9.05)**
CS19	Poor physical working condition	0.286	1.62	(0.67, 3.90)	0.114	2.00	(0.85, 4.73)
CS20	Lack of respect from subordinates	**0.000**	**7.67**	**(2.44, 24.09)**	**0.000**	**5.09**	**(2.19, 11.84)**
CS21	Workplace harassment	**0.002**	**4.33**	**(1.70, 11.04)**	0.098	1.97	(0.88, 4.38)
CS22	Workplace bullying	0.409	1.45	(0.60, 3.48)	0.296	1.56	(0.68, 3.56)
CS23	Work-home/life imbalance	0.478	1.42	(0.54, 3.76)	**0.016**	**4.13**	**(1.31, 13.02)**
CS24	Low income causing financial insecurity	**0.003**	**4.38**	**(1.66, 11.51)**	0.120	0.48	(0.19, 1.21)
CS25	Salaries not paid on time	**0.001**	**4.74**	**(1.90, 11.81)**	0.065	2.36	(0.95, 5.90)
CS26	Unsatisfactory living condition at home	**0.001**	**4.74**	**(1.90, 11.81)**	**0.009**	**3.78**	**(1.40, 10.18)**
CS27	Past traumatic experience	**0.000**	**10.40**	**(3.29, 32.84)**	**0.000**	**5.08**	**(2.14, 12.05)**
CS28	Marital relationship and challenges	**0.000**	**5.39**	**(2.10, 13.82)**	**0.001**	**4.75**	**(1.92, 11.76)**
CS29	Poor family connection or relationships	**0.001**	**4.82**	**(1.89, 12.32)**	**0.000**	**8.50**	**(3.16, 22.90)**
CS30	Lack of medical subsidies plan	**0.002**	**4.13**	**(1.68, 10.19)**	**0.004**	**4.25**	**(1.58, 11.42)**
CS31	Lack of opportunity for career development	**0.000**	**5.50**	**(2.18, 13.89)**	**0.002**	**6.00**	**(1.922, 18.73)**
CS32	Lack of opportunity for promotion	**0.000**	**6.48**	**(2.52, 16.65)**	**0.004**	**5.32**	**(1.70, 16.65)**
CS33	Lack of team or departmental or company social get-togethers	0.446	0.714	(0.30, 1.70)	**0.000**	**5.08**	**(2.148, 12.05)**

Note: OR- Crude odds ratio; CI- Confidence interval; CS- Cause of stress; *Numbers in bold are significant

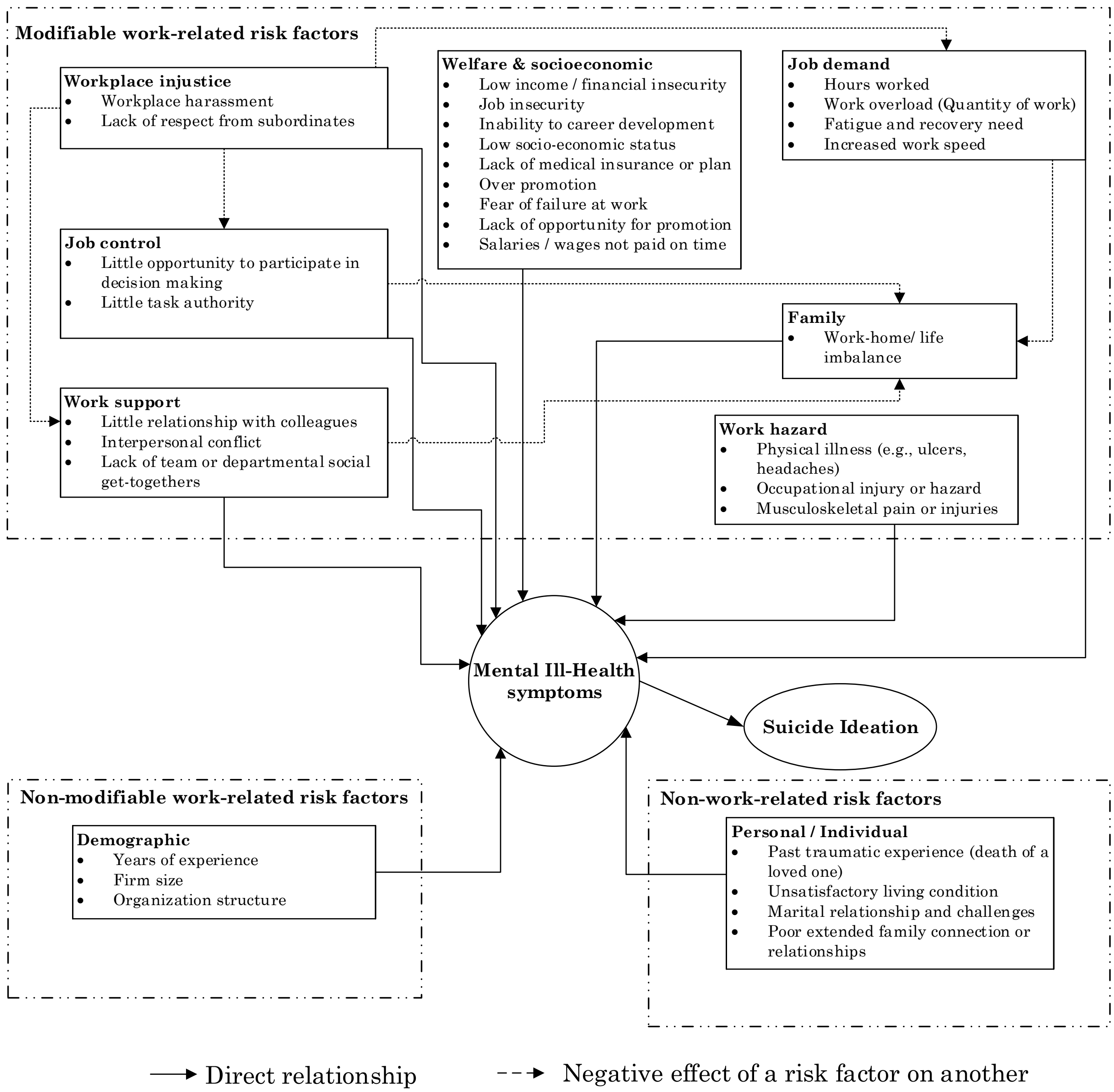

Figure 5. 2. A framework for mental ill-health among tradesmen

5.5 Discussion

5.5.1 Sources of stress among the supervisors

Work overload, increased work speed, low income, job insecurity, and poor working conditions (such as no leave, or allowances) were the top five causes of work stress among the construction personnel. This finding is to some extent consistent with Oladinrin et al. (2014) and Sunindijo and Kamardeen (2017), who identified low income, excessive workload, and high levels of time pressure as top stressors. These stressors have become prevalent in the construction industry globally, demonstrating the need for construction organizations to focus on them (Sunindijo and Kamardeen, 2017, Lingard et al., 2012, Sutherland and Davidson, 1993).

The results also show the influence of gender on the frequency of stressors experienced by construction personnel. Low income was the top three stressors among males, but it was ranked 17th by female respondents. Culturally, Nigeria is a highly patriarchal society where men are the main providers for their nuclear families and extended families (Akanle et al., 2018), making male professionals more subjected to the stress of low income, which can cause financial difficulties. Similar to Sunindijo and Kamardeen (2017), men perceived work-home/life imbalance as a higher stressor than their female counterparts. This indicates that male construction professionals, irrespective of the country, are subjected to working long hours, which may lead to work-home/life imbalance.

This study also confirms Lingard et al. (2007), who asserted that maintaining work-life balance in the construction industry is difficult for men because of the requirement to work for long hours. In addition, criticism from superiors was a stressor more frequently experienced by males than female professionals. It seems that male personnel may occupy lead team roles more often than females; thus, they are subjected to criticisms from superiors when there are shortcomings in their performance. The top sources of stress among females were working over 60hrs per week, little relationship with colleagues, nature of work, and little task authority. Some of the findings agree with Sunindijo and Kamardeen (2017), who deduced perceived low job autonomy and inadequate communication with colleagues as frequent causes of stress among female construction professionals.

5.5.2 Sources of stress among the tradesmen

Increased work speed, job insecurity, hours worked per day, work overload, physical illness caused by day's work, little opportunity to participate in decision making, and lack of opportunity for career development ranked as the top seven sources of stress among the tradesmen. These findings are consistent with those of previous studies that found that construction tradesmen experienced poor learning opportunities, future perspectives, lower participation in decision making (Boschman et al., 2013, Cheung and Yip, 2015), high work speed, workload, high job insecurity (Lim et al., 2017), and work more than 47 hours per week (Langdon and Sawang, 2018) than the general population or other professions. This may be high among the respondents because foremen are tasked with multiple roles involving carrying out their tasks and organizing their trade team. Although stress arising from job insecurity is pertinent in Nigeria, that among tradesmen may be worsened due to the industry's reliance on projects, where employment of this category of personnel is dependent on the availability of projects.

5.5.3 Mental ill-health symptoms and prevalence among the supervisors and tradesmen

Unlike the tradesmen where the PHQ-9 scores did not correlate with the GAD-2, among the supervisors, the PHQ-9 scores were moderately correlated with GAD-2 scores, implying that professional engaged in supervisory roles who had depression also had anxiety. This result is consistent with prior studies (Hughes et al., 2018, Choi et al., 2020) who have reported a co-morbidity of depression and anxiety, informing the call for further research to determine the unique and shared contributions of depression and anxiety to daily function and quality of life (Hughes et al., 2018).

Among the tradesmen and supervisors, the prevalence rate of depression was higher than anxiety symptoms. The result for tradesmen is consistent with an Australian study (Langdon and Sawang, 2018), that reported a higher mean for depression than anxiety among construction tradesmen. However, for the supervisors, this result is contrary to studies in the developed context, especially in Australia's construction industry (Kamardeen and Sunindijo, 2017) and United Kingdom (Rees-Evans, 2020), where anxiety appears to be more prevalent among professionals than depression. The result among the supervisors confirms Oladinrin et al. (2014), where professionals ranked depression higher than anxiety symptoms as a response to stress. Specifically in Oladinrin et al. (2014) depression ranked higher in third place than worsening anxiety that ranked ninth as a perceived impact of stress in the Nigerian construction industry.

The prevalence rate of depression in this study is consistent with Afolabi et al. (2008), Obadeji et al. (2015), and Dabana and Gobir (2018) that reported 59.9%, 47.7%, and 58.2% respectively among primary care settings and students in Nigeria. Regarding anxiety, Somoye et al. (2015) and Adewuya et al. (2018) reported a prevalence of 5.6% and 3.5%, respectively, among bank workers and the general public in Nigeria. Although the population in this study differs, it is evident that in Nigeria, depression is more prevalent than anxiety. The prevalence of depression in Nigeria may be due to cultural diversity, which causes poor interpersonal relations or increased job insecurity in the Nigerian workplace (Oyewunmi et al., 2015). Additionally, it may have been precipitated by the worsening socio-economic conditions in the country, which causes workers to smile while they suffer (Oyewunmi et al., 2015).

Among the supervisors and tradesmen, the presence of anxiety or depression was a risk factor for suicidal ideation. Among the tradesmen, GAD-2 scores and the suicide ideation scores were moderately correlated, implying that tradesmen with anxiety symptoms also experienced suicide ideation. Suicidal ideation had a prevalence rate of 16.8% among supervisors with depression symptoms and 9.2% across the construction supervisors' population. On the contrary, with a suicide ideation prevalence rate of 14.5% across the tradesmen population, this is higher than that deduced among the supervisors' population. The prevalence rate of suicidal ideation among the construction personnel is higher than 7.28% for the general population of Nigeria, deduced by Adewuya et al. (2016). This may be because blue-collar workers are associated with higher mental ill-health symptoms (Battams et al., 2014).

This study demonstrates that depression and anxiety were risk factors for suicidal ideation. However, depression was two times more likely than anxiety to cause suicidal ideation, as seen among supervisors. This finding is consistent with prior studies among other populations (Li et al., 2017, Chen et al., 2017a, Adewuya et al., 2016). Given that suicidal ideation is a significant predictor of actual suicide, this finding suggests that some personnel may be at risk of committing suicide. This signals that these common mental ill-health symptoms are an undetected challenge among construction personnel, and urgent interventions, such as mental health first aid and employee assistance program, are needed for preventing suicide in the Nigerian construction industry.

5.5.3 Mental ill-health risk factors among supervisors and tradesmen

Based on logistic regression, the study deduced that some stressors are risk factors for either depression, anxiety, or both. Consistent with the findings in other work settings, the risk factors for mental ill-health included non-work stressors (individual/personal), modifiable and non-modifiable work stressors (Considine et al., 2017, Cheung and Yip, 2015).

5.5.3.1 Demographic factors

Organizational structure, firm size, and years of experience are salient work-related risk factors for anxiety and depression (Battams et al., 2014, Rees-Evans, 2020). Of the demographic factors, organization structure emerged as a significant determinant of anxiety among supervisors, while years of experience and firm size emerged as significant determinants of anxiety and depression among tradesmen. This study suggests that tradesmen with fewer than 15 years and those with experience of more than 25 years were more likely to have anxiety and depressive symptoms than other tradesmen. Yoon and Kim (2013) suggested that younger and inexperienced nurses tend more than experienced nurses to exhibit mental ill-health symptoms. Thus, regarding the construction industry, tradesmen with experience less than 15 years may not have the requisite experience and resilience to cope with high job demand, low job support, low job control, and high workplace injustice in the construction industry. This study extends the literature by deducing that tradesmen with experience of over 25 years also tend to be more anxious. This may be because they may have family challenges that could interfere with work factors. For instance, older tradesmen would have children in tertiary institutions, which may subject them to increased financial commitments.

As regards firm size, Rees-Evans (2020) deduced that mental health in the construction industry worsened with decreasing firm size. Although Reez-Evans focused on professionals, this study extends the literature by deducing that tradesmen who work in micro-sized firms tended more to have anxiety symptoms. This may be due to the contractual arrangement in micro-sized construction firms, which tends to intensify the concerns of job insecurity among tradesmen. For instance, the post-survey interview indicated that tradesmen in micro-sized and small firms were engaged on a contract basis where sub-sections of the work (e.g., blockwork in sub or superstructure, tiling, iron bending) were awarded as labor-only contracts. However, their operations are subjected to total quality management involving strict supervision by the site supervisors or their assistants as though it were a direct-labor arrangement.

Additionally, the tradesmen were often not paid on time, which gives rise to conflicts between the tradesman and his subordinates (i.e., trade gang). The late payment of salaries may have resulted from the micro-sized firms experiencing late payments from their clients. For instance, Rees-Evans (2020) revealed that late payment affected the mental health of workers in small and medium firms. The businesses frequently experienced late payments, which resulted in the business owners often making sacrifices to pay their direct staff late (Rees-Evans, 2020). The tradesmen also do not sign any formal arrangement with the firms before accepting the labor-only contracts; neither do they have insurance. Thus, in the case of any disagreement, the tradesmen most times bear the entire risk of late payment of contract and wages to their crew. Such arrangement and related scuffles may be the reason for anxiety symptoms in the tradesmen.

As a firm's size increases, its organizational structure changes (Donaldson and Joffe, 2014, Beer, 1964). This study showed that tradesmen and supervisors engaged in pyramidal and matrix structure firms were more likely to have depressive symptoms than those in flat structured firms. This may be due to the intensity of work, complexity of the line of control in firms with pyramidal or matrix structure (Stuckenbruck, 1988). Thus, this study has revealed that as organizational structure complexity increases into a matrix structure, personnel in such firms may report increased poor mental health complaints. Although these risk factors are non-modifiable, this information will assist in ensuring that organizational measures to alleviate the possible effects of contractual arrangements, complex line of control or communication are implemented.

5.5.3.2 Job demand risk factors

Stressors related to job demand were associated with mental ill-health among supervisors and tradesmen. Construction tradesmen and supervisors who experience high job demand-related stressors (such as working long hours, work overload, increased work speed, and fatigue) were more likely to experience higher levels of depression and anxiety than others. This finding is consistent with Battams et al. (2014), Boschman et al. (2013), and Cohidon et al. (2010). Battams et al. (2014) reported that job overload was associated with poor mental health in male-dominated professions. Specifically, working for long hours and increased work speed is reported to increase depression (see Cohidon et al., 2010, Roche et al., 2016, Boschman et al., 2013).

Furthermore, Boschman et al. (2013) noted that induced fatigue caused by an intense need for recovery indicates an increased risk of mental health complaints among construction workers. This study advances Boschman et al. (2013) by revealing *fatigue resulting from work and poor recovery* as a risk factor for anxiety and depression. Thus, corroborating Techera (2017) and Bitsika et al. (2012) that individuals who are fatigued experience higher anxiety levels. This study implies that excessive job demand-related risk factors are prevalent among construction tradesmen and supervisors and need to be eliminated using appropriate primary intervention strategies.

5.5.3.3 Job control risk factors

Supervisors and tradesmen who experience low job control-related stressors were more likely to experience poor mental health than others. Specifically, lower task authority, lower decision-making opportunity, and strict adherence to time and schedules increased depression. Battams et al. (2014) reported that lack of job control in male-dominated professions was a predictor of poor mental health. Likewise, Niedhammer et al. (1998) found that a low level of decision latitude was a significant predictor of depressive symptoms in male and female workers. This further reinforces the need for interventions that give a worker more task control as they are likely to have positive effects on health and well-being, particularly mitigating anxiety and depression (Egan et al., 2007). Intervention strategies such as job sculpting and crafting can be employed to boost job control among construction personnel.

In hierarchy, those in manual occupations (e.g., tradesmen) are junior staff and have job roles and schedules assigned to them by the construction supervisor. However, supervisors can stir the feelings of job control and morale among the tradesmen by adopting properly planned job sculpting and crafting measures when assigning tasks.

5.5.3.4 Work support risk factors

Work support-related risk factors stemmed from stress relating to relationships among colleagues or supervisors, interpersonal conflict, social support, and social gatherings in the team environment. Specifically, supervisors and tradesmen who experience a lower relationship with colleagues were more likely than others to experience depression or anxiety. At the same time, tradesmen who experience interpersonal conflict or in a team environment with no social gatherings were more likely to develop anxiety symptoms than others. This aligns with studies that have found that exposure to violence, interpersonal conflict, and problematic work relationship influences depression in male-dominated industries and occupations (see Battams et al., 2014, Roche et al., 2016). Any form of work support in the workplace has been identified as a protective factor for mental health problems (Considine et al., 2017). Therefore, efforts to increase the feeling of support in the work environment, such as improving interpersonal relationships, swift conflict resolution, or team gathering during festive seasons or celebrations, could be adopted.

5.5.3.5 Workplace injustice risk factors

While acts of incivility did not appear to cause mental ill-health among supervisors, they negatively affected tradesmen. Acts of incivility (e.g., injustice) such as harassment, disrespect for subordinates in the construction industry have been identified as risk factors for mental ill-health among construction tradesmen and other manual occupations (Bryson and Duncan, 2018, Battams et al., 2014). Aligned with those studies, tradesmen who have been harassed were more likely to have depressive symptoms. Likewise, tradesmen whose subordinates have disrespected were more likely to have anxiety and depression. As revealed by the post-survey interview, a trend in developing countries is older tradesmen disrespecting a younger team leader as they claim they have more experience regarding construction production activities. Thus, while the team leader feels disrespected, the subordinate may also feel disrespected. Organizations must communicate policies that reinforce the line of authority and communication to eliminate workplace injustices. It is the top management's duty to set a culture that deals with any form of incivility (Bryson and Duncan, 2018). Therefore, as Nwaogu and Chan (2020) deduced, to make the construction workplace psychologically safe and healthy, strategies to eliminate workplace injustice should be implemented in Nigeria.

5.5.3.6 Welfare and socioeconomic related risk factors

This risk factor consists of work stressors that pertain to pay, working conditions, and career progression of tradesmen, which may affect the welfare of supervisors or tradesmen and their outlook among peers. This study revealed that supervisors or tradesmen who work in firms where they are subjected to stressors that challenge their welfare and socioeconomic status were more likely to experience depression or anxiety. Among construction frontline workers, Al-Maskari et al. (2011) found a relationship between monthly income and the likelihood of depression, as frontline workers who earned less than 500 UAE Dirham ($137) per month had depression. In Nigeria, personnel may face financial difficulties due to low income, which could be more apparent among married personnel, as the nation's patriarchal nature expects men to provide for their nuclear and extended families (Akanle et al., 2018). Nigeria is generally a lower-middle-income country; thus, measures to reduce the stress of low income could include financial management training and enrolling construction personnel in a sustainable retirement plan.

The study also found that personnel who experience job insecurity were at risk of developing depression and anxiety. This corroborates Meltzer et al. (2010) and (Roche et al., 2016), who pointed out that job insecurity is more strongly associated with feelings of depression than time pressure and workload. Overall, job insecurity is rampant in the Nigerian workplace because organizations continuously enhance their bottom line with fresh talents (Oyewunmi et al., 2015). However, job insecurity in the construction industry may be worse because supervisors and tradesmen are employed based on the availability of construction projects. Therefore, job insecurity is unavoidable in the construction industry. However, programs should be implemented in the workplace to prepare employees financially and mentally for the end of projects, including transition periods between jobs.

Lower socioeconomic status (Battams et al., 2014), lack of medical insurance (Tian et al., 2012), over-promotion, and fear of failure (Sutherland and Davidson, 1993) are associated with depression and anxiety. Supervisors or tradesmen with no medical subsidies were more likely to be depressive or anxious, corroborating Tian et al. (2012) that found that employees in China with basic health insurance were less likely to report depressive symptoms than others. Therefore, to boost employees’ morale, small and medium construction firms should provide basic health benefits to employees as part of their employment benefits. This study corroborates Sutherland and Davidson (1993) that reported that over-promotion and fear of failure among construction professionals were associated with anxiety. It also extends Sutherland and Davidson (1993) by revealing that they are also associated with depression among tradesmen. While over-promotion may arise from giving personnel jobs more than their skill set, the fear of failure may emanate from giving employees unrealistic deadlines to meet. Thus, adequate on-the-job training should be engaged to enable person-fit. Likewise, work schedules for construction projects should be planned with appropriate lead time to eliminate anxiety.

Among employees, poor working conditions such as little opportunity to promotion (Park et al., 2016), inability to career development (Redekopp and Huston, 2019), and late payment of salaries or wages (Banya and Elu, 1997) can negatively affect the mental health of workers. Late payment of wages threatens the sense of identity of men (Kiblitskaya, 2012), as it causes financial difficulties that can threaten mental well-being (Kim and You, 2019), with symptoms of depression among construction tradesmen as revealed in this study. Contrary to Rees-Evans (2020) who revealed that late payment practices affected the mental health of professionals working in small and medium construction firms, this study reveals that tradesmen are also affected.

Inability to career development negatively affects mental health (Redekopp and Huston, 2019). Thus, career development interventions focused on building self-awareness, decision-making, and fitting employees to the job, have greater contributions to well-being (Redekopp and Huston, 2019). Furthermore, limited opportunities for promotion, absence of job training, and other employee benefits such as retirement annuities create high job satisfaction and perceived stress, which may negatively affect employees' mental health (Park et al., 2016). Therefore, organizational policies directed at improving the working conditions to eliminate these risk factors are needed in the construction industry. Emphasis on such policies will create job satisfaction, boost morale, and enhance workplace well-being and productivity.

5.5.3.7 Family-related risk factors

The length of time and days an employee is supposed to work, non-standard work hours, and other job demand-related stressors diminishes family time and individual relaxation, thus damaging work-home/life and well-being (Kotera et al., 2020, Michie, 2002). In this study, supervisors and tradesmen that experience greater work-home/life imbalance were more likely to have anxiety than others. This finding confirms that work-life balance is an essential predictor of an employee's mental health. As noted in the UK construction industry by Kotera et al. (2020), workers with good work-life balance tended more to report lesser mental health problems. This indicates that job redesign measures like compressed working week arrangements could be adopted to ensure construction personnel have more time for their family and recover from stress. The findings of Nwaogu and Chan (2021a) show that job redesign measures, particularly compressed working week arrangement, may be more appropriate for the Nigerian construction workplace.

5.5.3.8 Work hazard related risk factors

This study's findings on work hazard-related risk factors confirm prior studies (Jacobsen et al., 2013, Hu et al., 2000, Boschman et al., 2013) that have found a link between occupational injury, musculoskeletal pain, and mental health. Major sources of hazard in the construction workplace are accidents (Boschman et al., 2013, Hu et al., 2000). Construction employees who have witnessed or experienced an occupational injury due to fatal accidents on construction sites suffer traumas that predict anxiety and depression (Boschman et al., 2013, Chan et al., 2020).

Occupational injury has been associated with anxiety symptoms (Shin et al., 2017). Likewise, this study revealed that supervisors or tradesmen who have witnessed or sustained an occupational injury were more likely to have mental ill-health symptoms, particularly anxiety or depression.

Jacobsen et al. (2013) reported that mental distress was associated with musculoskeletal pain in the back among construction frontline workers. While mental distress is unclassified, this study corroborates and extends Jacobsen et al. (2013) by revealing that musculoskeletal pain and injuries are associated with depression and anxiety symptoms. In developing countries like Nigeria, the prevalence of musculoskeletal pain and occupational injury is considered higher than in high-income countries (Manu et al., 2019, Ekpenyong and Inyang, 2014). Practical measures to mitigate musculoskeletal pain and occupational injury could include training on proper ways to lift materials, rehabilitation programs of injured personnel, adopting smart technology in preventing accidents and near misses, and the enforcement of design for safety regulations.

Supervisors and tradesmen who experienced physical illness related to their work were more likely to have higher levels of depressive symptoms. Prior studies (Goodwin, 2006, Al-Maskari et al., 2011) have also established that physical illness is a risk factor for depression. This emphasizes the need for robust health promotion and intervention policies to minimize excessive work pressure in the construction workplace. The study also found that supervisors exposed to increased mental demand arising from the nature of work were more likely to have depression. This finding aligns with Sunindijo and Kamardeen (2017), who found a positive correlation between the nature of work and depressive and anxiety symptoms. This implies that excessive mental demand in the construction industry is prevalent and detrimental to health, especially among site-based personnel engaged in building production (Boschman et al., 2013).

5.5.3.9 Individual related risk factors

Individual factors such as health status, life-event stressors (e.g., divorce and bereavement) (Battams et al., 2014), and downstream social determinants (e.g., living conditions, familial relationships) influence anxiety and depression (Alegría et al., 2018). Family relationships are a source of social support; thus, residing with family, satisfaction with family relationships, and connectedness are associated with fewer mental ill-health symptoms (Alegría et al., 2018). Aligning with these studies, supervisors, and tradesmen who have experienced bereavement, marital challenges, poor familial relationships, and unsatisfactory living conditions were more likely to have anxiety and depressive symptoms than others. Although these stressors are non-work-related, understanding their influence on the mental health of construction personnel is important. This will assist in building intervention strategies targeted at reducing work to home stressors and home to work stressors.

Multi-level intervention strategies involving training on self-esteem and EAP could be implemented. Although Employee Assistance Programmes provides support for non-work stressors, construction organizations could partner with non-profit mental health promotion agencies in Nigeria to offer appropriate interventions to supervisors and tradesmen for non-work stressors.

5.6 Chapter Summary

This study identified significant predictors of common mental ill-health amongst construction personnel engaged in building production management in Nigeria. The stress reaction for the majority of the respondents was depression within mild to moderate depressive symptoms. This study deduced that majority of the risk factors from the improved model were work-related. Thus, it can be concluded that work-related stressors were more likely than non-work-related stressors to cause mental ill-health among construction personnel in this context. Construction personnel working in pyramidal and matrix structure firms were more likely to experience poor mental health due to the complexity of their projects. Although organization structure is not a modifiable risk factor, policies that eliminate the fear of failure, role conflict, and bottlenecks in resource allocation should be implemented.

Given that risk factors do not emerge in isolation but rather clustered together, interventions aimed at promoting construction personnel's mental health should be directed toward the clusters of risk factors. Based on the findings, interventions to eliminate the risk factors for mental ill-health mitigation should focus on mental health literacy, anti-stigma campaigns, building individual resilience, introducing wellness programs to the workplace, stress management training, improving interpersonal relationships, utilization of annual leave, eliminating acts of incivility and employee assistant programs.

Additionally, to mitigate work-home/life imbalance and low task authority, intervention strategies that relate to job redesigning and job control should be adopted. Such strategies include adopting a compressed working week arrangement, job crafting, and job sculpting in the construction workplace. Maintaining the competitive advantage of construction organizations is difficult without a psychologically healthy workforce. Therefore, to strengthen policy-making, this study has investigated the impact of stress on site-based personnel's mental health in the Nigerian construction industry, determined the modifiable risk factors of mental ill-health, and recommended intervention strategies to mitigate them.

This chapter was used to achieve objective 1. It discussed the prevalence rate of mental ill-health symptoms and used logistic regression to deduce the stressors, which are risk factors for depression and anxiety among 174 supervisors and tradesmen. The succeeding chapter (Chapter 6) is a continuation of Chapter 5 but discusses the protective factors for mental health.

CHAPTER 6: PROTECTIVE FACTORS FOR MENTAL HEALTH AMONG SUPERVISORS AND TRADESMEN[13]

6.1 Introduction

Construction professionals engaged in site management positions are subjected to heightened work stress and related mental ill-health symptoms due to the industry's demanding nature (Boschman et al., 2013, Haynes and Love, 2004). When left unmanaged, stress could become excessive, posing a severe risk to individuals and organizations (Cattell et al., 2016, Watson et al., 2008, Hannigan et al., 2004). On the individual level, the impact includes safety incompliance, reduced performance, psychological and physiological health consequences (Haynes and Love, 2004). The risk to organizations includes lower productivity, increased sick leave, lost-work hours, and compensations (Liang et al., 2021, Chan et al., 2020).

The source of stress includes long working hours, poor physical work environment, little social support (Campbell, 2006, Love et al., 2010, Boschman et al., 2013), work-family/life imbalance (Lingard et al., 2007), financial insecurity (Langdon and Sawang, 2018), job insecurity (Haynes and Love, 2004), interpersonal conflict (Chen et al., 2017c), bullying and harassment (Kamardeen and Sunindijo, 2017). Irrespective of the intensity of stress which employees experience, they are affected differently because some people appear to cope better than others

[13] This chapter is based on the articles mentioned below produced by the author of the thesis during the PhD study:
Nwaogu, J. M., Chan, A. P. C. and Tetteh, M. O. 2021. Staff resilience and coping behavior as protective factors for mental health among construction tradesmen. *Journal of Engineering, Design and Technology*. https://doi.org/10.1108/JEDT-11-2020-0464.
Nwaogu, J. M. and Chan, A. P. C. Under Review. Evaluating How Coping Strategies and Individual Resilience affects Anxiety and Depression among Construction Supervisors. *Journal of Civil Engineering and Management*. SCEM-2021-0043.

(Haynes and Love, 2004). The variation results from the coping strategy adopted and inherent coping resource (such as resilience) in each individual.

Over the years, to alleviate stress, attention has focused on stress-coping behaviors employed to manage poor mental health problems among construction professionals (Haynes and Love, 2004, Sunindijo and Kamardeen, 2017). Haynes and Love (2004), considering cognitive coping, found that among site managers in Australia, adopting emotion-focused strategies increased depression and anxiety, while problem-focused strategies reduced anxiety and depression. Of the existing literature relating to stress-coping behaviors and mental ill-health among construction supervisors and/or tradesmen, neither has considered the role of resilience in the stress-coping process nor has been conducted in Nigeria.

Resilience has been associated with coping skills; it influences high positive coping skills (Chen et al., 2017b). During adverse events, resilience influences how an individual appraised the stressor, whereas coping refers to the strategies employed after appraising the stressor (Thompson et al., 2018). Resilience mediates and moderates the relationship between coping strategies and psychological outcomes (Wu et al., 2020, Tian et al., 2019, Smith et al., 2016). Evidence shows that high resilience predicts the use of social support and PFC strategies for good mental health outcome, hampers the use of EFC strategies (Thompson et al., 2018, Rabenu and Yaniv, 2017, Wu et al., 2020, Gloria and Steinhardt, 2016, Li and Miller, 2017).

In Nigeria, the construction sector is strategic to alleviating unemployment and increasing GDP (Olanipekun and Saka, 2019). However, the prevalence of work factors that causes stress among construction personnel may deter the industry's contribution to the Nigerian economy (Ibem et al., 2011, Ojo et al., 2019, Oladinrin et al., 2014). The coping strategy that a site supervisor or tradesman will implement, depends on their resilience level and how they appraise the stressor, resulting in enhanced or decreased mental health (Rabenu and Yaniv, 2017). Therefore, understanding how site supervisors and tradesmen cope with stress to alleviate the negative mental health and well-being impact becomes imperative.

With this research objective, this study aimed to identify the ability of resilience and coping strategies to protect site supervisors and tradesmen against mental ill-health. In order to achieve this aim, the objectives were: (i) to determine the coping strategies employed and their effects on mental ill-health symptoms (i.e., depression and anxiety); (ii) to examine the effect of resilience on the likelihood of developing mental ill-health symptoms; (iii) to determine the effect of resilience on coping strategies among site supervisors. The objectives were further achieved by testing the hypothesis stated in section 2.6.2.4. The result of this study would benefit the construction industry on two levels. The individual-level benefit includes improved safety compliance, increased performance, improved psychological and physiological health; increased productivity, reduced lost-work hours, and compensations at the organization level.

6.2 Research Design

As described in Section 4.9, the quantitative methodology was adopted. Th questionnaire survey was used to solicit information from construction site supervisors and tradesmen engaged in construction projects. The research instruments employed for this study include the Patient Health Questionnaire (PHQ-9), Generalized Anxiety Disorder (GAD-2), Brief Resilience Scale (BRS), and excerpts from the Ways of Coping Questionnaire (WCQ).

6.2.1 Data collection

Out of the 550 and 453 copies of questionnaires administered to supervisors and tradesmen, a total of 174 and 110 questionnaires were retrieved, respectively.

6.2.2 Data analysis

The data were analyzed using descriptive statistics and inferential statistics. The descriptive statistics employed are mean score and chi-square analysis; the inferential statistics are univariate logistic regression and conditional process analysis. In analyzing data using logistic regression, the respondents were classified into two groups, each as described in Section 4.6.4.6.

6.3 Results for Supervisors

6.3.1 Mental ill-health symptoms and resilience level among the supervisors

As shown in Table 6.1, the prevalence rate of mild depression among supervisors was 65 (37.4%), 27 (15.5%) for moderate depression, and 3 (1.7%) for moderately severe depression. The mean score for the PHQ-9 was 5.33 ± 3.80, indicating that, on average, the level of depression in the population was within the mild range. The mean score for the GAD-2 was 1.20 ± 1.39, indicating that the anxiety level was within the minimal level on average. Only 16 (9.2%) of the respondents experienced suicidal ideation. The BRS revealed that 44 (25.3%) of the respondents had high resilience level, 75 (43.1%) normal resilience level, and 55 (31.6%) low resilience. The mean score for the BRS score was 3.64 ± 0.90, indicating that, on average, the resilience level was within the normal level.

Table 6. 1: Demographic, mental ill-health, and resilience characteristics of the supervisors

Variable	Categories	Frequency (%)	Mean (SD)
Demographics characteristics			
Sex	Male	158 (90.8)	
	Female	16 (9.2)	
Mental ill-health symptoms			
Depression (0, 17)			5.33 (3.80)
	None-Minimal (0-4)	79 (45.4)	
	Mild (5-9)	65 (37.4)	
	Moderate (10-14)	27 (15.5)	
	Moderately severe (15-19)	3 (1.7)	
	Suicide ideation	16 (9.2)	
Anxiety (0, 6)			1.20 (1.39)
	None-minimal (0-2)	149 (85.6)	
	Mild-moderate (≥ 3)	25 (14.4)	
Resilience	Low resilience (≥2.99)	55 (31.6)	
	Normal resilience (3.00 - 4.30)	75 (43.1)	
	High resilience (4.31 - 5.00)	44 (25.3)	

6.3.2 Association between individual resilience, mental-ill health symptoms, suicidal ideation, and demographic variables

Table 6.2 details the result of this section. The Chi-square or Fisher test revealed a statistically non-significant relationship between two demographic factors (years of experience, gender), individual resilience and mental health symptoms. As shown in Table 6.2, there existed a statistic relationship between suicidal ideation and depression (χ^2 = 10.90, p = 0.01), and anxiety (χ^2 = 18.18, p = 0.00). Likewise, Pearson's correlation between depression, anxiety, and suicide ideation was 0.25, 0.32, respectively, indicating a statistical relationship between mental ill-health symptoms and suicidality. Univariate regression showed that respondents with depression and anxiety were approximately 15 times and 8 times likely to experience suicidal ideation.

Table 6. 2: Exploring the association between demographic variables, resilience, mental-ill health symptoms, and suicidal ideation

	Depression	No Depression	χ^2 or F	p	COR	Anxiety	No Anxiety	χ^2 or F	p	COR	Resilience	No Resilience	χ^2 or F	p	COR
Personnel (n = 174)	95 (54.6)	79 (45.4)				25 (14.4)	149 (85.6)				119 (68.4)	55 (31.6)			
Gender			2.08	0.19				1.62	0.25^{F}				1.35	0.28	
Male (n = 158)	89 (56.3)	69 (43.7)				21 (13.3)	137 (86.7)				106 (67.1)	52 (32.9)			
Female (n = 16)	6 (37.5)	10 (62.5)				4 (25.0)	12 (75.0)				13 (81.3)	3 (18.8)			
Education			3.13	0.38				5.37	0.15				0.42	0.94	
HND (n = 43)	23 (53.5)	20 (46.5)				9 (20.9)	34 (79.1)				29 (67.4)	14 (32.6)			
PGD (n = 19)	8 (42.1)	11 (57.9)				3 (15.8)	16 (84.2)				12 (63.2)	7 (36.8)			
BSc/Tech (n = 67)	35 (52.2)	32 (47.8)				11 (16.4)	56 (83.6)				46 (68.7)	21 (31.3)			
MSc/Tech (n = 45)	29 (64.4)	16 (35.6)				2 (4.4)	43 (95.6)				32 (71.1)	13 (28.9)			
Years of experience			2.54^{F}	0.79				7.03^{F}	0.16				5.81^{F}	0.31	
1-5yrs (n = 46)	24 (52.2)	22 (47.8)				4 (8.7)	42 (91.3)				35 (76.1)	11 (23.9)			
6-10yrs (n = 66)	38 (57.6)	28 (41.8)				11 (16.7)	55 (83.3)				42 (63.6)	24 (36.4)			
11-15yrs (n = 41)	24 (58.5)	17 (41.5)				7 (17.1)	34 (82.9)				27 (65.9)	14 (34.1)			
16-20yrs (n =10)	5 (50.0)	5 (50.0)				-	10 (100)				5 (50.0)	5 (50.0)			
21-25yrs (n = 4)	1 (25.0)	3 (75.0)				-	4 (100.0)				4 (100)	-			
> 25yrs (n = 7)	3 (42.9)	4 (57.1)				3 (42.9)	4 (57.1)				6 (85.7)	1 (14.3)			
Suicidal Ideation			**10.90**	**0.00**	0.25^{a}			**18.18**	**0.00***	0.32^{a}			1.20	0.40	-0.08
No (n =158)	80 (50.6)	78 (49.4)				17 (10.8)	141 (89.2)				110 (69.6)	48 (30.4)			
Yes (n = 16)	15 (93.8)	1 (6.3)				8 (50.0)	8 (50.0)				9 (56.3)	7 (43.8)			

	Suicidal Ideation		
	p	cOR	95% CI
Depression	0.01	14.63	1.89-113.39
Anxiety	0.00	8.29	2.76-24.96

Note: p = p-value; COR = correlation; a = correlated significant at 0.01; bold values are significantly different at 0.01; χ2 = Chi-square; F = Fisher Exact test and score; CI = Confidence level; cOR = Crude Odds ratio; HND = Higher National Diploma; PGD = Post-Graduate Diploma; BSc/Tech = Bachelor degree; MSc/Tech = Master degree.

6.3.3 Coping strategies employed and their effects on mental health among supervisors

Mean score analysis revealed that the supervisors' top five ranking coping strategies (C8, C6, C5, C4, C2) were related to PFC behaviors of *positive reappraisal*. In contrast, as shown in Table 6.3, the least ranking strategies were related to EFC strategies. Univariate logistic regression showed that PFC skills of *planful problem-solving* (OR=0.09), *positive reappraisal* (OR=0.17), and *seeking social support* (OR=0.29) were significant predictors for reduced odds of anxiety symptoms (see Table 6.3). Construction supervisors who employ the PFC skills were only 0.09 times, 0.17 times, 0.29 times likely to experience anxiety.

On the contrary, EFC strategies related to *accepting responsibility* (OR=2.28) and *avoidance coping skills* (OR=2.69; OR=4.06) were significantly associated with elevated odds of anxiety and depression symptoms. Supervisors who employ *accepting responsibility skills* were only 2.28 times more likely to experience anxiety. In comparison, supervisors who employ *avoidance skills* were 2.69 times and 4.06 times more likely to experience depression and anxiety symptoms, respectively. This indicates that the PFC-related skills are negatively associated with mental ill-health symptoms, while EFC strategies were positively related to mental ill-health symptoms. Thus, supporting hypothesis $H2_1$.

Table 6. 3: Mean score analysis of coping strategies, odds ratios for an absence of mental ill-health due to resilience, and coping strategies among supervisors

Cod	Description	Suicidal Ideation P	Suicidal Ideation OR	95% CI	Regression Analysis Depression P	OR	95% CI	Anxiety p	OR	95% CI
R	**Resilience**									
	Low resilience	-	-		-	-		-	-	
	Normal resilience	0.54	0.71	0.23-2.14	0.51	0.79	0.39-1.60	0.56	0.76	0.31-1.88
	High resilience	0.18	0.33	0.64-1.66	0.66	0.47	0.21-1.05	**0.03**	**0.19**	**0.04-0.91**

Cod	Description	Descriptive Statistics Mean	R	Depression P	OR	95% CI	Anxiety p	OR	95% CI
	Problem-focused coping								
	Planful problem-solving								
C01	Knew what had to be done, so I doubled my efforts to make the thing work	3.11	8	0.74	1.22	0.38-3.94	**0.00**	**0.09**	**0.03-0.31**
C02	Came out with a couple of diff solutions to the problem	3.22	5	0.99	-	-	0.99	0.00	-
C03	Made a plan of action and followed it	3.14	7	0.79	1.21	0.29-5.02	0.39	0.48	0.09-2.54
	Positive reappraisal								
C04	Came out of the experience better than when I went in	3.28	4	0.53	1.54	0.40-5.93	0.78	1.36	0.16-11.38
C05	Changed or grew as a person in a good way	3.28	3	0.68	0.60	0.53-6.70	0.37	0.33	0.03-3.74
C06	Rediscovered what is important in life	3.29	2	0.51	1.84	0.30-11.27	0.13	0.24	0.04-1.49
C07	Found a new faith	2.57	18	0.80	1.09	0.56-2.11	0.15	2.27	0.74-7.00
C08	Prayed to withstand or succeed	3.35	1	0.99	1.00	0.29-3.42	**0.00**	**0.17**	**0.05-0.60**
	Seeking social support								
C09	Talk to someone who could do something concrete about the problem	2.83	13	0.79	0.85	0.26-2.79	0.29	0.47	0.12-1.88
C10	Talk to someone to find out more about the situation	2.77	14	0.07	0.79	0.85-5.31	**0.04**	**0.29**	**0.09-0.93**
C11	Talk to someone about how I was feeling	2.62	16	0.16	2.15	0.75-6.20	0.35	2.69	0.34-21.30
	Confrontive coping								
C12	Expressed anger to the person who caused the problem	2.05	22	0.26	1.45	0.75-2.79	0.49	1.41	0.53-3.77
C13	Tried to get the person responsible to change his or her mind	2.59	17	0.36	1.50	0.63-3.57	0.16	4.38	0.56-34.00
	Emotion-focused coping								
	Accept responsibility								
C14	Realized I had brought the problem on myself	2.11	21	**0.02**	**2.28**	**1.17-4.41**	0.47	0.72	0.30-1.76
C15	Criticized or lectured myself	2.84	11	0.66	1.23	0.49-3.13	0.23	3.51	0.45-27.45
C16	I made a promise to myself that things would be different next time	3.16	6	0.99	0.00	0.00	0.72	0.66	0.07-6.18
	Escape- Avoidance								
C17	Wished that the situation would go away or somehow be over	2.99	9	0.99	0.29	1.03-3.48	0.99	-	-
C18	I had fantasies about how things might turn out	2.83	12	0.25	1.76	0.67-4.62	0.99	-	-
C20	Tried to lose myself for a while by smoking	1.39	25	0.67	0.85	0.41-1.79	0.12	2.13	0.83-5.43
C21	Used alcohol to make myself feel better	1.35	26	0.18	1.66	0.79-3.46	0.22	1.79	0.71-4.53
C22	Tried to make myself feel better by eating	2.01	23	0.08	1.73	0.94-3.20	**0.01**	**4.06**	**1.33-12.42**
C23	Let my feelings out like crying or venting my emotions	1.76	24	**0.00**	**2.69**	**1.44-4.99**	0.83	0.91	0.39-2.14
	Self-controlling								
C19	Kept others from knowing how bad things were	2.43	20	0.25	1.59	0.73-3.46	0.80	1.16	0.37-3.66
	Distancing								
C24	Didn't let it get to me and refused to think about it too much	2.52	19	0.61	1.24	0.54-2.86	0.99	-	-
C25	Went on as if nothing had happened	2.75	15	0.99	1.00	0.41-2.46	0.19	3.94	0.51-30.68
C26	Made light of the situation and refused to get too serious about it	2.87	10	0.96	1.03	0.33-3.21	0.91	0.92	0.19-4.41

Note: *Reference category; Numbers in bold are significant; cOR- Crude odds ratio; CI- Confidence interval. The coping items are sourced from Leung et al. (2006), Chan et al. (2014), and Folkman et al. (1986).

6.3.4 Resilience and mental health among supervisors

Although normal resilience level was not statistically significantly related to anxiety, it was deduced that as resilience level increased, the odds ratio of experiencing anxiety reduced (see Table 6.3). High resilience was significantly associated with reduced anxiety level; thus, supporting hypothesis $H2_2$. Specifically, supervisors with high level of resilience were only 0.19 times likely to experience anxiety symptoms. Chi-square test, Pearson correlation, and univariate logistic regression showed that individual resilience level was not statistically significantly related to suicide ideation (see Table 6.3). Likewise, univariate logistic regression showed that individual resilience level was not statistically significantly related to depression.

6.3.4.1 Association between individual resilience, coping strategies and mental health among supervisors

Resilience was positively related to *positive reappraisal* and *planful coping* and negatively related to *avoidance coping strategies*. Thus, supporting Hypothesis $H2_3$. As shown in Table 6.4, high resilience scores were related to reduced odds of employing EFC behaviors related to *avoidance coping* (OR= 0.46) and increased odds of employing PFC behaviors related to *planful coping* (OR=17.2) and *positive reappraisal* (OR=20.09). Resilience accounted for 22.6%, 20.4%, and 3.5% variance in *planful problem-solving*, *positive reappraisal*, and *avoidance strategies*, respectively.

Table 6. 4: Univariate association between individual resilience and coping strategies

	Emotion-focused			Problem-focused					
	Escape- Avoidance			Planful problem-solving			Positive reappraisal		
Resilience	p-value	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI
Low *									
High	**0.047**	**0.46**	**0.22, 0.99**	**0.01**	**17.21**	**2.06, 143.6**	**0.01**	**20.09**	**2.44, 165.0**
Overall model									
R → CP	R^2 = 0.035, 2LI = 170.835			R^2 = 0.204, 2LI = 53.478			R^2 = 0.226, 2LI = 57.172		
CP → R	R^2 = 0.031, 2LI = 213.255			R^2 = 0.089, 2LI = 205.691			R^2 = 0.106, 2LI = 203.446		

Note: *reference category; Numbers in bold are significant; OR- Crude odds ratio; CI- Confidence interval; R → CP = Resilience predicts coping strategy; CP → R = Coping strategy predicts resilience; Low = No resilience group; High = Resilient group.

Hypothesis $H2_4$ was partially supported as it was deduced that resilience did not mediate the relationship between any of the coping strategies and mental ill-health symptoms. Instead, it can moderate the relationship (see Table 6.5 and Appendix IV). For instance, it was found that the interaction term (*planful problem-solving* coping skill (CP1) x resilience) between resilience and *planful coping* skill CP1 accounted for 19.9% variance in anxiety. A significant interaction effect was noted between resilience and *planful problem-solving* skill (CP1) in predicting anxiety (β = -3.26, se = 1.49, p = 0.03), indicating that resilience is a moderator.

Since the interaction effect is negative, it implies that the more positive resilience becomes (i.e., the higher the resilience level), the more negative effect *planful problem-solving* coping skill (CP1) has on anxiety. At high levels of resilience (1), the relationship between *planful problem-solving* coping skill (CP1) and anxiety was significant (β = -4.06, se = 1.15, p = 0.000). At low levels of resilience (0), the relationship between planful problem-solving coping skill and anxiety was not significant (β = -0.80, se = 0.94, p = 0.396). The conditional effect shows that, at high level of individual resilience, *planful problem-solving* coping skill (CP1) makes the supervisors experience less anxiety. To visualize the conditional effect of the coping strategy, a scatter plot of CP1 with anxiety by resilience was generated (see Figure 6.1).

Figure 6.1 shows that there is no association between CP1 and anxiety among supervisors with low resilience. In contrast, there was a negative association between CP1 and anxiety among supervisors with high resilience, indicating that the *planful problem-solving* coping skill (CP1) was associated with reduced anxiety for them.

Table 6. 5: Testing the moderating effect of resilience in the coping process

Model summary						
-2LL	ModelLL	df	p	McFadden	CoxSnell	Nagelkrk
122.5892	20.6423	3.0000	.0001	.1441	.1119	.1994
	Coeff	se	z	P	LLCI	UPCI
Constant	-0.693	0.866	-0.800	0.424	-2.391	1.004
CP1	-0.799	0.941	-0.848	0.396	-2.644	1.047
Res	2.303	1.396	1.649	0.099	-0.434	5.040
Int_1	-3.258	1.486	-2.193	0.028	-6.170	-0.347
Likelihood ratio test(s) of highest order unconditional interactions(s):						
	Chi-sq	df	p			
X*W	5.7393	1.0000	0.0166			
Conditional effects of the focal predictor at values of the moderator(s):						
Res	Effect	se	Z	P	LLCI	ULCI
.0000	-0.7985	0.9413	-0.8483	0.3963	-2.6435	1.0465
1.0000	-4.0566	1.1492	-3.5298	0.0004	-6.3091	-1.8042

Note: Dependent variable (Y) = Anxiety; Independent variable (X) = Planful coping skill (CP1); Moderator (W) = Resilience (Res); Int_1: CP1 x Resilience

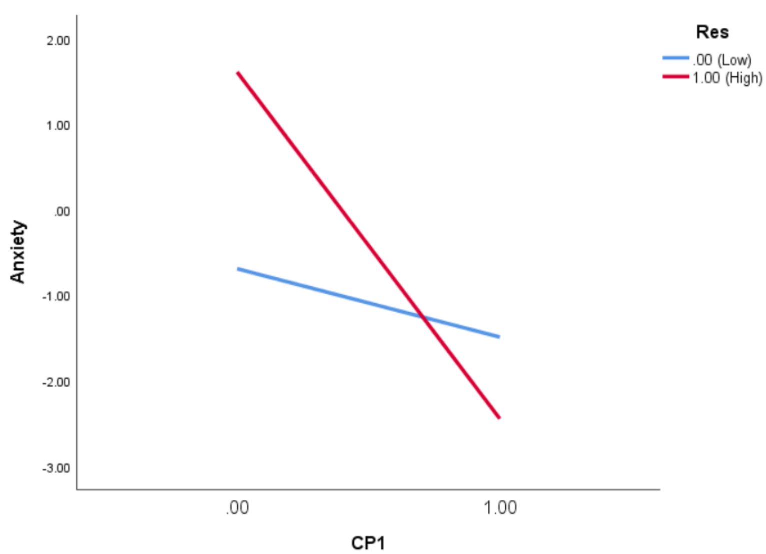

Figure 6. 1: Moderating effect of resilience on the relationship between a planful coping skill (CP1) and anxiety. Higher scores on the y-axis equal higher levels of anxiety.

6.4 Results for Tradesmen

6.4.1 Mental ill-health symptoms among the tradesmen

As shown in Table 6.6, the prevalence rate of mild depression was 57.3%, 12.7% for moderate depression, and 4.5% for moderately severe depression. Using GAD2, the prevalence rate of none-minimal anxiety was 63.6%, and 36.4% for anxiety. The study revealed that 18.2% of the tradesmen had low resilience (BRS score 1.00-2.99), 60.0% normal resilience, and 21.8% high resilience.

Table 6. 6: Demographic, mental ill-health, and resilience characteristics of the tradesmen

Variable	Categories	Descriptive analysis			
		Frequency (%)	Mean (SD)	Pearson Correlation	p-value (2-tailed)
Demographics characteristics					
Sex	Male	110 (100.0)			
Mental ill-health symptoms					
Depression			1.93 (0.71)		
	None-Minimal (0-4)	28 (25.5)			
	Mild (5-9)	63 (57.3)			
	Moderate (10-14)	14 (12.7)			
	Moderately severe (15-19)	5 (4.5)			
	Suicide ideation	16 (14.6)			
Suicide ideation	Several days	6 (5.5)			
	More than half the days	10 (9.1)			
Anxiety			1.36 (0.48)		
	None-minimal (0-2)	70 (63.6)			
	Mild-moderate (≥3)	40 (36.4)			
Anxiety-Suicide ideation				0.33	0.00
Resilience	Low resilience (≥2.99)	20 (18.2)			
	Normal resilience (3.00 - 4.30)	66 (60.0)			
	High resilience (4.31 - 5.00)	24 (21.8)			
Resilience-Suicide ideation				-0.27	0.01

6.4.2 Demographic variables associated with resilience, depression, and anxiety among tradesmen

The Chi-square or Fisher test revealed a statistically significant relationship between the two demographic factors (years of experience, education level) and resilience (see Table 6.7). The preliminary bivariate analysis revealed that the level of resilience is associated with mental health status. As shown in Table 6.7, tradesmen with normal and high levels of resilience were less likely to be anxious or depressive. There existed a statistic difference between resilience and depression (χ^2 = 9.77, p = 0.01), anxiety (χ^2 = 18.02, p = 0.00), and suicide (χ^2 = 8.33, p = 0.01) with a significant difference between the groups. The posthoc test revealed the difference between groups. As regards anxiety, tradesmen with high resilience and normal resilience were significantly different (χ^2 = 17.64, p = 0.000; χ^2 = 10.24, p = 0.006) compared to low resilience. Likewise, for depression, high resilience was significantly different (χ^2 = 9.61, p = 0.008) compared to normal and low resilience. Fisher's test and correlation analysis (r = -0.27, p = 0.01) revealed that as the level of resilience increased, the likelihood of suicide ideation reduced (see Table 6.6 and Table 6.7).

There existed statistical differences between years of experience (χ^2 = 14.74, p = 0.02), level of education (χ^2 = 15.51, p = 0.01), and resilience, with no significant difference between each of the groups. Regarding mental health status, there is a statistical difference between depression (χ2 = 24.76, p = 0.00), anxiety (χ2 = 22.49, p = 0.00), and years of experience with a significant difference between the groups. Tradesmen with work experience less than 20 years (p = 0.000) were more likely to have depressive symptoms. In contrast, younger tradesmen with less than 15 years of work experience (p = 0.001) and older tradesmen with more than 25 years (p = 0.002) were likely to have anxiety symptoms.

Table 6. 7: Demographic characteristics according to mental health and resilience among tradesmen

	Depression		Anxiety		Resilience	
Characteristics	χ^2 or Fisher's	α	χ^2 or Fisher's	α	χ^2 or Fisher's	α
Years of experience	**24.76***	**0.00**	**22.49***	**0.00**	**14.74***	**0.02**
Education	5.54*	0.13	3.60*	0.31	**15.51***	**0.01**
Resilience	**9.77**	**0.01**	**18.02**	**0.00**		
Suicide					**8.33***	**0.01**

Note: Bold values are significantly different at <0.05 (two-tailed); χ^2 = Chi-square test; * Fisher's Exact test; α = p-value; Freq. = Frequency.

6.4.3 Coping strategies employed and their effects on mental health among tradesmen

As shown in Table 6.8, the top five coping strategies employed by the tradesmen include: came out of the experience better than when I went in, prayed to withstand or succeed, talked to someone to find out more about the situation, knew what had to be done, so I doubled my efforts, made a promise to myself that things would be different next time ranked with mean scores of 3.33, 3.25, 3.25, 3.24, 3.20 respectively. These topmost ranking strategies are forms of problem-focused coping strategies. The majority of the coping strategies had a minimum mean value of 2.00 on a 4-point Likert scale (see Table 6.8). The least ranked coping strategies were "*tried to lose myself for a while by smoking cigarettes*" and "*consumption of cannabis to ease stress"* with a mean of 1.71 and 1.36, respectively.

As shown in Table 6.8, problem-focused forms of coping, such as positive reappraisal strategy like "*came out of the experience better than when I went in*" (COR = 0.25, 95% CI: 0.10 - 0.63) was associated with reduced odds of anxiety. In contrast, positive reappraisal strategy, "*found a new faith,*" was associated with increased odds of anxiety (COR = 3.18) and depression (COR = 5.39) symptoms. Planful problem-solving strategies were not significantly associated with increased risk of depression and anxiety among the construction tradesmen. Confrontive coping, especially "*expressed anger to the person who caused the problem,*" was associated with increased risk of depression (COR = 3.64, 95% CI: 1.42 – 9.34) and anxiety (COR = 9.91, 95% CI: 2.20 - 44.66) among the construction tradesmen.

Emotion-focused coping forms, such as avoidance, self-controlling, and distancing strategies, were significantly associated with increased odds of anxiety. On the one hand, avoidance strategy "*fantasies about how things might turn out*" (COR = 5.40) was significantly associated with an increased risk of depression. On the other hand, *alcohol consumption* (COR = 2.25), *cannabis consumption* (COR = 3.22), and *venting of emotions* (COR = 13.50) were each significantly associated with an increased risk of anxiety. As shown in Table 6.8, anxiety was significantly related to self-controlling strategy "*kept others from knowing how bad things were* (COR = 4.33)" and distancing strategies "*didn't let it get to me and refused to think about it too much*" (COR = 9.50), "*went on as if nothing had happened*" (COR = 3.64) and "*made light of the situation and refused to get too serious about it* (COR = 6.48)."

Although most PFC-related skills did not mitigate mental ill-health symptoms, one PFC-related skill was negatively associated with mental ill-health symptoms. Also, EFC strategies were positively related to mental ill-health symptoms. Thus, hypothesis $H2_1$ was supported.

Table 6. 8: Mean score analysis of coping strategies, odds ratios for an absence of mental ill-health due to resilience, and coping strategies among tradesmen

Code	Variables	Descriptive Statistics		Univariate regression					
		Mean	R	Depression			Anxiety		
	Resilience			p	OR	95% CI			
R	Low resilience*								
	Normal resilience			0.86	1.13	0.31-3.97			
	High resilience			**0.04**	**0.25**	**0.06- 0.97**			
	Coping Strategies								
	Problem-based coping								
	Plan problem solving								
CP01	Knew what had to be done, so I doubled my efforts to make the thing work	3.24	4	0.99	0.00	-	0.99	0.00	-
CP02	Came out with a couple of different solutions to the problem	3.09	10	0.99	0.00	-	0.99	0.00	-
CP03	Made a plan of action and followed it	3.18	7	0.99	0.00	-	0.41	0.55	0.13, 2.31
	Positive reappraisal								
CP04	Came out of the experience better than when I went in	3.33	1	0.48	1.42	0.54, 3.76	**0.03**	**0.25**	**0.10, 0.63**
CP05	Changed or grew as a person in a good way	3.15	8	0.99	0.00	-	0.82	1.16	0.33, 4.13
CP06	Rediscovered what is important in life	3.05	11	0.99	0.00	-	0.99	0.00	
CP07	Found a new faith	2.38	19	**0.00**	**5.39**	**2.09, 13.82**	**0.01**	**3.18**	**1.35,7.47**
CP08	Prayed to withstand or succeed	3.25	2	0.99	0.00	-	0.87	1.15	0.20, 6.59
	Seeking social support								
CP09	Talked to someone who could do something concrete about the problem	3.18	6	0.99	0.00	-	0.99	0.00	-
CP10	Talked to someone to find out more about the situation	3.25	3	0.99	0.00	-	0.30	0.53	1.59, 1.77
CP11	Talked to someone about how I was feeling	3.02	12	0.99	0.00	-	0.80	0.84	0.22, 3.19
	Confrontive coping								
CP12	Expressed anger to the person who caused the problem	2.38	20	**0.00**	**3.64**	**1.42, 9.34**	**0.03**	**9.91**	**2.20, 44.66**
CP13	Tried to get the person responsible to change his or her mind	2.85	13	0.99	0.00	-	0.52	1.50	0.44, 5.14
	Emotion-based coping								
	Accept responsibility								
CP14	Realized I had brought the problem on myself	2.13	21	0.41	1.45	0.60, 3.48	0.06	2.25	0.95, 5.31
CP15	Criticized or lectured myself	2.67	15	0.99	0.00	-	0.73	1.19	0.46, 3.08
CP16	Made a promise to myself that things would be different next time	3.20	5	0.99	0.00	-	0.27	2.45	0.49, 12.16
	Escape- Avoidance								
CP17	Wished that the situation would go away or somehow be over	3.09	9	0.06	5.07	1.58, 16.28	0.99	-	-
CP18	I had fantasies about how things might turn out	2.69	14	**0.01**	**5.40**	**1.99, 14.66**	0.06	3.12	0.97, 9.98
CP20	Tried to lose myself for a while by smoking	1.71	26	0.19	0.55	0.23, 1.34	0.22	1.67	0.74, 3.78
CP21	Used alcohol to make myself feel better	2.09	23	0.59	1.27	0.54, 3.02	**0.04**	**2.25**	**1.02, 4.97**
CP27	Consumed cannabis to ease stress	1.36	27	0.99	-	-	**0.01**	**3.22**	**1.33, 7.82**
CP22	Tried to make myself feel better by eating	2.04	24	0.09	1.97	0.88, 4.38	0.15	1.88	0.79, 4.48
CP23	Let my feelings out like crying or venting my emotions	1.89	25	0.60	2.31	0.97, 5.53	**0.00**	**13.5**	**4.33, 42.1**
	Self-controlling								
CP19	Kept others from knowing how bad things were	2.11	22	**0.00**	**4.33**	**1.70, 11.04**	0.09	1.97	0.88, 4.38
	Distancing								
CP24	Didn't let it get to me and refused to think about it too much	2.53	17	**0.00**	**9.50**	**3.10, 29.07**	0.77	1.17	0.43, 3.41
CP25	Went on as if nothing had happened	2.40	18	**0.00**	**3.64**	**1.49, 8.89**	0.11	2.00	0.85, 4.73
CP26	Made light of the situation and refused to get too serious about it	2.56	16	**0.00**	**6.48**	**2.52, 16.65**	0.69	1.20	0.50, 2.90

Note: * Reference category; the reference category for coping strategy is No. Therefore, all results are for yes (i.e., of each strategy); Numbers in bold are significant; OR- Crude odds ratio; CI- Confidence interval; p = p-value.

6.4.4 Resilience and mental health among tradesmen

The univariate logistic regression analysis revealed that a high level of individual resilience (COR = 0.25, 95% CI: 0.06-0.97) was significantly associated with reduced odds of depression (see Table 6.8). Although the resilience data did not fit into the regression model for anxiety, Chi-square revealed an association between resilience and anxiety symptoms. Thus, supporting hypothesis $H2_2$ as high resilience was significantly associated with reduced anxiety and depression level.

6.4.5 Impact of resilience on coping strategy among tradesmen

The resilience of tradesmen had a significant positive association with positive reappraisal coping strategy and a negative association with self-control behavior. Thus, supporting Hypothesis $H2_3$. As shown in Table 6.10, resilience was associated with increased odds of employing problem-focused coping forms, such as positive reappraisal strategy (COR = 5.00). In contrast, resilience was associated with reduced odds of employing emotion-focused coping forms, such as self-controlling strategy (COR = 0.06). Therefore, as shown in Table 6.10, tradesmen with normal and high resilience employed were 4.50 and 5.00 times, respectively, more likely to engage positive reappraisal behavior. In contrast, tradesmen with high resilience employed were 0.06 times likely to engage self-controlling strategies.

Table 6. 9: Univariate association between resilience and coping strategies among tradesmen

Resilience	**Problem-focused**			**Emotion-focused**		
	Positive reappraisal			Self-controlling		
	p-value	cOR	95% CI	p-value	cOR	95% CI
Low resilience*						
Normal resilience	**0.06**	**4.50**	**(1.53, 13.21)**	0.42	0.15	(0.54, 4.33)
High resilience	**0.02**	**5.00**	**(1.25, 19.99)**	**0.00**	**0.06**	**(0.01, 0.33)**

Note: * Reference category; Numbers in bold are significant; cOR- Crude odds ratio; CI- Confidence interval.

6.5 Discussion

Due to the limited number of studies investigating stress-coping and mental ill-health among supervisors and/or tradesmen in the construction industry, some comparisons had to be made outside the construction work field. The analysis revealed that (i) resilience could directly or indirectly protect against suicidality (ii) resilience, seeking social support, positive reappraisal, and accepting responsibility mitigated the likelihood of negative stress outcomes (anxiety, depression, and suicide ideation) by ensuring positive stress response. Thus, acting as protective factors; and (iii) the adoption of problem-focused and emotion-focused coping strategies by supervisor and tradesmen also acted as risk factors, as the strategies predicted mental ill-health symptoms.

6.5.1 Demographic factors influencing resilience, and mental health among supervisors and tradesmen

Education level and years of experience influenced the resilience among tradesmen but did not influence resilience among supervisors. As regards the demographic factors, the influence of education on resilience among tradesmen, agrees with the finding of Ren et al. (2018) among nurses but contradicts Ren and colleagues' assertion that years of experience do not influence resilience. Since there exists some relationship between age and experience (Cheung and Yip, 2015) tradesmen with experience less than 15 years may lack the requisite emotional expertise to deal with pressure from work and related mental ill-health (Bowen et al., 2014c, Chan et al., 2020). Contrary to studies (Ren et al., 2018, Li et al., 2017, Cheung and Yip, 2015) which suggested that years of experience and gender predict anxiety, depression, or resilience, among the supervisors, the demographic characteristics were not significantly associated with individual resilience and mental ill-health symptoms.

6.5.2 Mean scores of coping strategies adopted by the supervisors and tradesmen

Among the tradesmen, problem-focused coping strategies related to planful problem solving, positive reappraisal, seeking social support, and emotion-based coping strategies related to accepting responsibility ranked as the most commonly used coping behaviors. In contrast, supervisors most frequently used problem-focused coping strategies related to planful problem solving and positive reappraisal. Among both groups, the least frequently used strategies were related to avoidance. This finding corroborates Tsaras et al. (2018), who deduced that positive re-evaluation, positive approach, problem-solving, and seeking social support had the highest mean score among nurses while the least employed strategies included avoidance strategy. Similar to Lim et al. (2017), the preferred coping behavior among tradesmen following seeking social support relates to emotion-based coping, especially accepting responsibility. Owing to the labor-intensive nature of construction, tradesmen are risk-takers, enabling them the prowess to employ problem-focused coping (Lim et al., 2017). This may be because tradesmen work in stressful conditions and under varying weather conditions, enabling them to adjust to happenings mentally.

6.5.3 Mental ill-health among supervisors and tradesmen

Based on logistic regression, the study deduced the role of coping strategies and resilience in protecting against either depression, anxiety, or both. An interesting finding of this study among tradesmen is the univariate analysis indicating that substance abuse and alcohol intake increased the risk of anxiety. Contrary to Langdon and Sawang (2018), where substance abuse was associated with better mental health among tradesmen. Overall, this study's results agree with prior research, which suggests that when dealing with workplace stress, problem-focused coping strategies are more likely than emotion-focused to be associated with better mental health (Tsaras et al., 2018). Consistent with the findings in other work settings, resilience, and problem-focused strategies appeared to protect against mental ill-health among tradesmen.

6.5.3.1 Resilience and mental health

Resilience was an apparent protective factor for mental health, as supervisors and tradesmen with increased resilience were less likely to experience depressive and anxiety symptoms as well as suicide ideation. Thus, supporting hypothesis $H2_2$. This finding corroborates previous studies that have established that higher levels of resilience are associated with reduced depression and anxiety (McDowell et al., 2019, Ran et al., 2020, Schure et al., 2013, Li and Miller, 2017). Although the resilience level among the supervisors was not significantly associated with depression or suicidal ideation, it was noticed that as the level of resilience increased from normal to high, the odds of experiencing depression or suicidal ideation reduced. This further confirms that high resilience is associated with reduced mental ill-health.

Additionally, resilience was found to be a significant predictor of coping strategy. The higher the resilience level of tradesmen or supervisors, the more likely they were to employ *positive reappraisal*, *planful problem-solving* and reduce the use of *avoidance* coping skills and self-controlling skills. Therefore, fulfilling hypothesis $H2_3$. This finding corroborates Rabenu and Yaniv (2017) and Ren et al. (2018), who noted that problem-focused behaviors are positively associated with high resilience, while low resilience is associated with avoidance coping (emotion-focused) techniques. Therefore, organizations may consider training and awareness activities that can improve individual resilience and cognitive coping skills to mitigate the impact of stressors on employees' mental health and performance on the job.

6.5.3.2 Coping strategies and mental health

Problem-focused coping strategies were protective against anxiety, as supervisors who employed skills related to *planful problem-solving*, *positive reappraisal*, and *seeking social support* were less likely to experience anxiety than those who did not utilize the skills to cope with stress. On the contrary, emotion-focused strategies acted as a risk factor for mental ill-health because supervisors and tradesmen who employed emotion-focused behaviors were more likely to experience anxiety or depression than others who do not utilize them. Particularly, supervisors who utilized emotion-focused coping behaviors relating to *accepting responsibility* and *avoidance* and tradesmen who used *avoidance, self-controlling,* or *distancing* were more likely to experience anxiety or depression symptoms than others. This finding supports hypothesis $H2_1$.

The finding echoes studies (Haynes and Love, 2004, Sunindijo and Kamardeen, 2017, Langdon and Sawang, 2018) that found that adopting emotion-focused coping strategies among construction professionals increased depression and anxiety, while PFC strategies reduced anxiety and depression. The finding among tradesmen is consistent with Langdon and Sawang (2018), who deduced that behavioral disengagement is significantly associated with poor mental health symptoms (anxiety and depression). Emotion-focused coping forms have been identified to be associated with poor mental health symptoms when dealing with stress among the working population (Tsaras et al., 2018). This may result from the maladaptive nature of emotion-focused strategies because they do not focus on the personal growth needed to withstand stressors and prevent related mental ill-health adequately. Although PFC and EFC are often used interchangeably (Folkman et al., 1986, Biggs et al., 2017), training programs in the construction industry must elucidate the importance of intensifying the use of PFC strategies.

Additionally, tradesmen who employed positive reappraisal strategies such as "*came out of the experience better than when I went in*" were less likely to experience anxiety. This finding negates Langdon and Sawang (2018), who found that positive reframing was associated with increased anxiety among tradesmen in Australia. This study's finding aligns with Tsaras et al. (2018), who noted that a positive reappraisal strategy is more likely to mitigate anxiety. This may be because this form of strategy consciously regulates emotions (Nowlan et al., 2016, Nowlan et al., 2015), thereby focusing on personal growth by intentionally reappraising the situation to identify positive gain.

Tradesmen who employed a positive reappraisal strategy, "*finding a new faith,"* were more likely to experience depressive and anxiety symptoms. This aligns with Tsaras et al. (2018), who found that the positive reappraisal strategy's religious tone predicted an increased risk of depressive symptoms. This may be because there are harmful forms of religious coping linked to psychological distress (Pargament et al., 2011). On the contrary, among supervisors, "*prayed to withstand or succeed,"* which is a religious tone appeared to protect against anxiety. Furthermore, problem-focused coping strategies involving confrontive behavior predicted anxiety among the tradesmen, as those who "*expressed anger to the source of stressor or problem*" were more likely than others to experience anxiety symptoms. This agrees with Liang et al. (2021), who noted that adopting confrontive coping behavior in the face of stress among construction workers does not seem to remedy it but escalates it. Thus, according to Whittington and Wykes (1994), confrontive coping may be a problematic strategy since it is linked to increased anxiety.

The study hypothesized that resilience would mediate or moderate the relationship between coping strategy and mental ill-health symptoms. However, its result contradicted previous literature (e.g., Chen et al., 2019), showing the mediation ability of resilience by deducing that resilience did not mediate. Instead, resilience acted as a moderator in the case of a skill related to problem-focused coping strategy. The hypothesis ($H2_4$) was fulfilled in a *planful problem-solving* skill, as resilience heightened the negative relationship between the *planful problem-solving* and anxiety. Specifically, there is a negative association between planful problem-solving coping skill and anxiety among supervisors with high resilience. This finding negates Li and Miller (2017) predictions that although resilience will moderate the relationship between coping skills and anxiety, a stronger relationship between the coping strategy and anxiety will be observed among people with a low level of resilience.

This study confirms that persons with a high level of resilience were more likely to gain more mental health benefits from adaptive strategies (Smith et al., 2016). Thus, it highlights the need to invest in mental health education and resilience training to enhance effective problem-focused coping behaviors among construction personnel.

6.6 Chapter Summary

This current study revealed that the protective factors for mental health among the tradesmen and supervisors comprise resilience and problem-focused coping strategies. Surprisingly, none of the coping strategies appeared to protect against depression symptoms. Based on the result, it can be deduced that if the protective factors form the basis for mental health intervention in the construction workplace, the negative impact of work and non-work stressors on mental health can be mitigated and prevented. Thus, these coping strategies and resilience-building should form the basis for secondary interventions targeted towards supervisors and tradesmen in the industry.

The study confirmed that resilience is a vital coping resource. Although over three-quarters of the respondents tended to report normal and high resilience levels, less than a quarter of the respondents had high levels of resilience. Hence, there is a need to deploy interventions toward increasing the level of individual's resilience in Nigeria's construction industry. This will include educating construction personnel (i.e., supervisors and tradesmen) on the importance of optimism, pre-stress inoculation training, workplace coaching, and workplace physical activity interventions (Glozier and Brain and Mind Centre, 2017). The proven benefit of resilience training includes reducing burnout by fostering mental preparedness, improving relaxation techniques, cognitive coping skills, appropriate lifestyle modifications, and improving safety (Chen et al., 2017b). Hence, building individual resilience skills of construction personnel through some of the mentioned techniques can improve cognitive coping skills and resilience.

Although the tradesmen adopted problem-focused coping forms more frequently, adopting the strategies did not appear to effectively control the adverse effect of stress. Thus, it is necessary to empower tradesmen with practical means of applying problem-focused coping forms for efficient stress reduction and workplace safety benefits. For instance, to spur the use of problem-focused coping forms, management teams should consult construction workers while assigning jobs and safety plans (Liang et al., 2021). Therefore, primary intervention strategies such as job crafting could be adopted for tradesmen for a psychologically healthy construction workforce (Nwaogu and Chan, 2021a). This will serve two major purposes: (i) provide job control and support opportunities, and (ii) practically equip construction tradesmen with planful problem-solving skills to deal with stressors for effective results.

Additionally, tradesmen and supervisors should be educated on the positive and negative forms of religious coping and the best means to adopt such coping for improved health benefits. This is important because Nigerians have great ties to religious inclination (Akah and Ajah, 2020), so personnel will often opt for religious coping skills in the face of stress. Notably, the interventions in the construction industry should reinforce the disadvantages of adopting emotion-focused strategies, especially those that appeared to escalate the likelihood of developing poor mental health among the personnel.

This chapter was used to achieve objective 1. It discussed the prevalence rate of resilience and used logistic regression to deduce the relationship between resilience, coping strategies and mental ill-health symptoms. The logistic regression was used to determine if resilience, the problem-focused strategies, or emotion-focused strategies mitigated the likelihood of developing depression or anxiety. If the odds ratio is less than one and p-value is less than 0.05, a protective ability of resilience or coping strategies is achieved. The succeeding chapter (Chapter 7) discusses objective two of the research study.

CHAPTER 7: EFFECT OF WORK PRESSURE ON PHYSIOLOGICAL HEALTH[14]

7.1 Introduction

The working population is subjected to daily stress that impacts bodily physiological response. The physiological reactions are mediated through sense hormones and sympathetic nervous system activity, which benefits health (Poitras and Pyke, 2013). However, the physiological responses are more harmful if they persist for a long time, as chronic activation of the response increases exposure to physical and mental ill-health. Such physical ill-health includes cardiovascular diseases, fatigue, and sleep problems, while mental ill-health symptoms include distress, depression, and anxiety (Garza et al., 2015, Järvelin-Pasanen et al., 2018). Work stress is an established psychosocial work problem in the construction industry (Petersen and Zwerling, 1998, Garza et al., 2015, Jebelli et al., 2018b), owing to the demanding nature of the work activities (Jebelli et al., 2018b).

Irrespective of how stressed construction personnel gets, the only natural way to recover is through sleep (Powell and Copping, 2016). Sleep restorative strength has been noted as a prerequisite to daily functioning and good health (Bowen et al., 2018). The ability to sleep appropriately for adequate recovery is affected by excessive work pressures during the day, consequently increasing error rates, accidents, weakening the immune system, and reducing productivity (Basner et al., 2014, Alhola and Polo-Kantola, 2007). The rate of fatalities, sick leave,

[14] This chapter is based on the article mentioned below produced by the author of the thesis during the PhD study: Nwaogu, J. M. and Chan, A. P. C. 2021b. Work-related stress, psychophysiological strain, and recovery among on-site construction personnel. *Automation in Construction,* 125**,** 103629. https://doi.org/10.1016/j.autcon.2021.103629.

and suicide in the construction industry are heightened compared to other industries (Hwang et al., 2016, Boschman et al., 2013, Nwaogu et al., 2019b). They occur due to poor recovery, mental ill-health symptoms, frequent use of drugs, and alcohol induced by chronic work stress (Meina et al., 2020, Boschman et al., 2013). Hence, understanding the psychophysiological health impact of occupational stress by studying autonomic arousal and recovery sleep becomes imperative for preventive occupational health and safety care.

Therefore, this study aims to determine the impact of work (job) pressure on the physiological health of on-site construction personnel to inform interventions necessary for maintaining good health and well-being. To achieve the aim, the following objectives were set: (i) determine the psychophysiological strain of workload operationalized by heart rate variability; (ii) assess recovery from work pressure operationalized through sleep score (i.e., sleep quality). The study demonstrates the possibility of using physiological indicators to evaluate recovery abilities. Therefore, it proposes (i) an inexpensive means to monitor sleep quality for health management purposes, especially in developing countries; (ii) emphasizes the need for a flexible work-rest cycle; (iii) proposes variables and model that can form a basis to track psychophysiological strain and impact on recovery. The objectives were further achieved by testing the hypothesis stated in section 2.8.4.

7.2 Research Design

This study was conducted to achieve objective two of the research. As described in Section 4.9, positivism and pragmatic philosophies were used to guide the study. Thus, the quantitative and qualitative methodology, which involved experiments and post-experiment interviews, were adopted. The research population consisted of construction site supervisors and tradesmen. The experimental instruments included two wearable devices that had been previously validated. The two wearable devices selected are 1) Polar H10 heart rate monitor manufactured by Polar Electro Oy, Finland, and 2) Fitbit Alta HR activity tracker.

7.2.1. Data collection and analysis

The data was collected from 56 healthy adult male participants (i.e., 28 of the 110 skilled tradesmen and 28 of the 174 site supervisors/engineers). The personnel were engaged in activities related to their job duties, such as site supervision, masonry, tiling, iron bending, concreting, carpentry, plaster of paris fixing. The data collected was analyzed using (i) descriptive statistics, particularly mean score and standard deviation, spearman's rank correlation coefficient, and inter-group comparison tests in SPSS 20.0 statistical package; (ii) linear and multiple regression in open-source R software; and (iii) narrative syntheses for the post-experiment interviews.

7.3 Results

Although the normality of the data collected could be determined using the Kolmogorov-Smirnov test of normality since the sample size was above 50, the Shapiro-Wilk test was employed because of the slight discrepancies between Shapiro-Wilk and Kolmogorov-Smirnov tests (Nwaogu and Chan, 2021b). After checking the histogram and Q-Q plots, the Shapiro-Wilk test was employed to mitigate a Type II error.

7.3.1 Average HRV and sleep data

Fifty-six participants in two separate groups provided HRV and sleep data for a combined 7683 mins and 20150 hours, respectively. The participants' age ranged from 24 to 57 years, with an average BMI of 26.97 ± 1.95. The participants were subjected to an average of 51.5 ± 9.5 %HRR. Supervisors were exposed to an average of 49.4 %HRR, while the tradesmen faced 53.6 ± 9.3 %HRR (see Table 7.1). As shown in Table 7.1, although the %HRR between the groups was not significantly different, the impact of the work pressure on each personnel group resulted in a significantly different HRV among tradesmen ($HRV_{composite}$ = 47.1 ± 9.0) compared to the supervisors ($HRV_{composite}$ = 55.1 ± 7.3). Overall, this is evident by higher frequency domain metrics, a significantly lower HF_{power}, higher LF_{power} (normalized and percentage), and significantly lower time-domain frequency metrics (i.e., Mean R-R, SDNN, SDNNI, and RMSSD parameters), among the tradesmen than supervisors.

Compared to the supervisors, tradesmen were subjected to significantly higher sympathetic activity (LF_{power}), and lower parasympathetic activity (HF_{power}) clustered around the high physical stress zone on the LF-HF graph. With a 71.7% LF, 14.5% HF, tradesmen had an increased sympathovagal balance (LF/HF) of 6.4, resulting from high LF (see Figure 7.1). With HF of 23.1%, supervisors appeared to experience significantly increased parasympathetic activity (i.e., resting times) from physical demands during work than tradesmen. This may have resulted from the difference in work schedules as tradesmen were more engaged in physically demanding work involving repetitive movements in varying positions than supervisors who engage more in mentally demanding jobs in seated positions. Overall, the 56 participants had a stress index averaged 12.6 ± 3.9, with tradesmen subjected to a significantly higher stress index than supervisors (see Table 7.1). Spearman's rank correlation coefficient showed that there is a statistically significant ($r = 0.470$, $p = 0.001$) positive correlation between stress index and %HRR.

The 56 participants averaged 6.9 ± 1.41 hours (416.8 ± 84.3mins) time in bed, out of which only 6 ± 1.23 hours (360 ± 74mins) were TST after work with a significant difference between tradesmen and supervisors. The tradesmen slept for an average of 381.9 ± 76.9mins, while supervisors averaged TST of 337.8 ± 65.4 mins. Both personnel groups had an average awake time (WASO) of 54.1 ± 16.0mins, with supervisors averaging WASO of 51.1 ± 14mins, while tradesmen averaged WASO of 57.1 ± 17.5mins. The participants averaged 238.5 ± 76.3mins in light sleep, amounting to an average of 66% TST with a significant difference between the groups. Supervisors spent a lower time in light sleep, averaged 207 ± 53.9mins and 62% TST, while tradesmen averaged 269.3 ± 83.7mins in light sleep and approximately 71% TST. An average of 67.9 ± 27mins was spent in deep sleep, accounting for an average of 19% TST, with a significantly higher time spent in this stage among tradesmen.

In the deep sleep stage, tradesmen averaged 74.0 ± 25.0mins, approximately 17% TST, while supervisors averaged 61.8 ± 28.1mins, amounting to 18% TST. In the REM sleep stage, supervisors averaged 68.2 ± 15.9mins (20% TST), while tradesmen averaged 66.4 ± 23.8mins (17% TST). Based on the time spent in the different sleep stages and TST, the 56 participants averaged a sleep score of 74.0 ± 7.1% within the "fair sleep quality" range. Notably, tradesmen averaged a sleep quality of 73.9 ± 7.9%, while supervisors averaged 74.1 ± 6.4%. With sleep efficiency (SE) averaged 90 ± 4.8%, all participant groups did not show any sign of insomnia.

Table 7. 1: Average HRV and sleep data of 56 participants

Parameters	Unit	All participants	Tradesmen	Supervisors	Significance test
BMI		27.0 (2.0)	**26.3 (2.1)**	**27.8 (1.6)**	0.001[a]
Stress index		12.6 (3.9)	**14.0 (4.3)**	**11.2 (2.9)**	0.036[b]
$HRV_{composite}$		51.1 9.1)	**47.1 (9.0)**	**55.1 (7.3)**	0.001[a]
%HRR	%	51.45 (9.5)	53.6 (9.3)	49.4 (9.2)	0.099
HRV Time-domain parameters					
Mean RR	bpm	697.6 (96.0)	**646.5 (93.3)**	**748.9 (68.1)**	0.000[a]
SDNN (STDRR)	ms	32.7 (13.1)	**26.6 (9.5)**	**38.7 (13.5)**	0.001[b]
SDNNI	ms	54.2 (15.3)	**50.1 (14.9)**	**58.3 (14.9)**	0.046[a]
RMSSD	ms	25.1 (17.3)	**17.5 (7.6)**	**32.8 (20.4)**	0.000[b]
HRV Frequency-domain parameters					
LFnu	n.u	82.4 (10.9)	**86.0 (9.5)**	**78.7 (11.1)**	0.011[b]
HFnu	n.u	21.9 (10.5)	**17.5 (8.4)**	**26.2 (10.7)**	0.000[b]
LF power	%	70.3 (8.5)	**71.7 (7.9)**	**69.0 (9.1)**	0.001[b]
HF power	%	18.8 (9.7)	**14.5 (7.3)**	**23.1 (9.9)**	0.000[b]
LF/HF		5.1 (2.6)	**6.4 (2.8)**	**3.7 (1.5)**	0.000[b]
Sleep data					
Sleep Score (SC)	%	74.0 (7.1)	73.9 (7.9)	74.1 (6.4)	0.911
Light sleep (N1+N2)	min	238.5 (76.3)	**269.3 (83.7)**	**207.8 (53.9)**	0.007[b]
Deep score N3	min	67.9 (27.0)	**74.0 (25.0)**	**61.8 (28.1)**	0.045[b]
REM	min	67.3 (20.1)	66.4 (23.8)	68.2 (15.9)	0.731
WASO	min	54.1 (16.0)	57.1 (17.5)	51.1 (14.0)	0.159
SE	%	90.0 (4.82)	88.9 (4.8)	91.1 (4.7)	0.083
TST	min	359.8 (74.1)	**381.9 (76.9)**	**337.8 (65.4)**	0.025[a]
TIB	min	416.8 (84.3)	**444.73 (85.7)**	**388.9 (74.2)**	0.012[a]

Bold figures are significant at $p < 0.05$; [a] Significant at $p < 0.05$ using Independent T-test; [b] Significant at $p < 0.05$ using the Mann-Whitney U test.

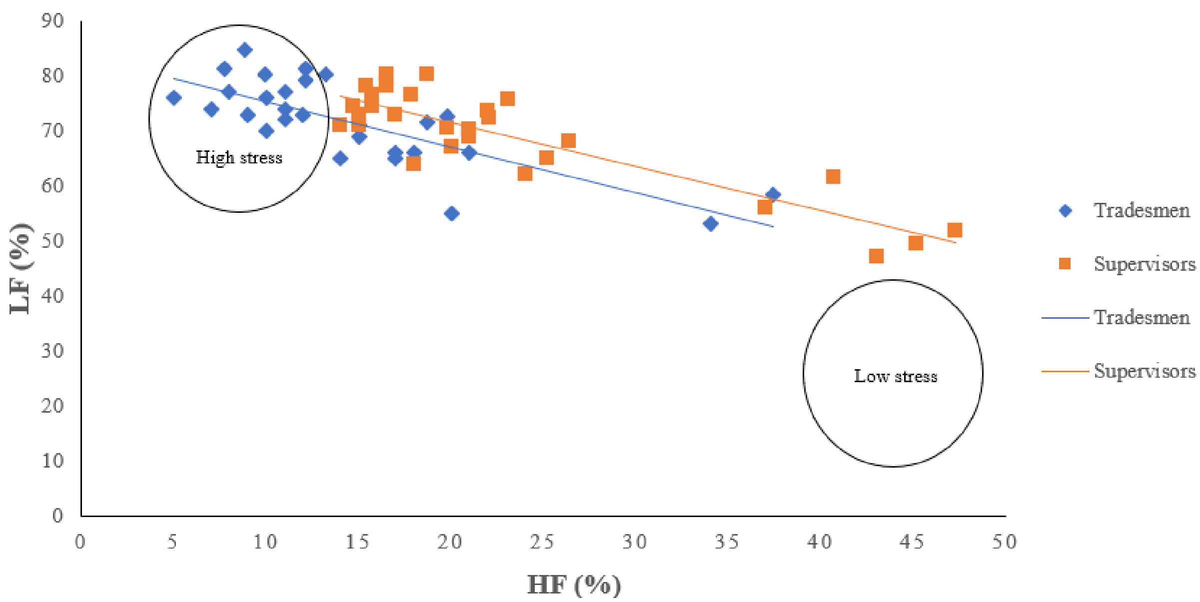

Figure 7. 1: The LF-HF graph indicating stress categorization in 2D

7.3.2. Post-experiment interview

A narrative synthesis of the interview on sleep habits provides insights into reasons why supervisors tended to sleep late as deduced from the activity tracker. The reasons include religious activities, watching soccer matches, and preparing for professional qualifications. More than tradesmen, supervisors tended to get out of bed early for prayers or beat the traffic. Unlike the supervisors who had to travel to work sites, all tradesmen resided in the site accommodation, so they did not have to set out early to beat traffic. Some interview transcript on post-work factors that may influence sleep duration includes:

"You know we sleep here on-site and only go to our family every Saturday evening or fortnightly. I don't have anything to do after I close from work; I just have a bath, contact my family on the phone, then gist a bit with colleagues, go out to eat, or stroll. Like most of us, once it is about 9.00 pm, I go to sleep till 5.00 am when I prepare to go to the mosque nearby or pray on-site, after that, I rest till about 6.30 am when most of us begin to prepare for resumption" (Tradesmen- interviewee #4).

"I usually don't sleep for long; I find myself waking up around 3.00 am, and so I decided to turn it to praying at midnight. Sometimes, I go back to sleep before waking again at about 5.00 am to prepare to beat traffic. I will like to learn how to sleep properly. Honestly, the prayers are good, but I picked it up because I tend to wake at the same time and felt God wanted me to pray" (Supervisor-interviewee #1).

"I usually don't sleep early even when I am sleepy; I force myself not to sleep because I have to watch the English premier league, or La-Liga Premiership league, which finishes late in the night because of time zone difference. Thank God, this is Abuja, and I live here in town just

Wuse II, so I can sleep till 6.30 am before I get up and prepare for work. I still get to the site before 8 am" (Supervisor- interviewee #9).

7.3.3. Regression analysis findings

7.3.3.1. HRV-sleep data

The combined HRV and sleep data were analyzed for correlation and predictive modeling. Using the R software, multiple regression analysis was used to evaluate the significant relationship between HRV and sleep, and the results are presented in Table 7.2. During the multiple regression analysis, independent variables (i.e., HRV parameters) were checked for multicollinearity. It was deduced that only four HRV parameters, namely Mean R-R, SDNNI, HF, LF/HF had VIF below 10 (see Table 7.2). Thereafter, the HRV and sleep score analysis revealed a significant relationship ($p < 0.05$) between Mean RR, SDNNI, LF/HF, and sleep score, while HF was not significantly associated with sleep score. The HRV-Sleep score model indicates that all things being held constant, for 30 units increase in Mean R-R, 5 units increase in SDNNI, and 0.4 unit increase in LF/HF, sleep score increased by one unit (see Table 7.2).

HRV-Sleep efficiency analysis deduced that only SDNNI, HF, and LF/HF, had a statistically significant association with sleep efficiency (see Table 7.2). With 31.3 units increase in Mean RR, 4.1 units increase in HFpercent, and 0.7 unit increase in LF/HF, sleep efficiency increased by 1 unit. HRV-Deep sleep analysis revealed a significant interaction between deep sleep and three HRV parameters (SDNNI, HF, and LF/HF). There was a significant increase in deep sleep by one unit per 1.2 units increase in SDNNI, 0.74 unit increase in HF percent, and 0.16 unit increase in LF/HF, all things being held constant.

Additionally, HRV-REM analysis showed a significant interaction ($p < 0.05$) between Mean R-R, LF/HF, and REM sleep stage. With all things being held constant, one unit increase in REM sleep resulted from 12 units increase in Mean RR and 0.25 unit increase in LF/HF. All the models were adjusted for BMI and age, but there was no significant effect observed.

Table 7. 2: Relationship between work stress, sleep quality, and sleep architecture

		Dependent variables (Sleep parameters)											
		Sleep score			Sleep efficiency			Deep sleep			REM		
		β	s.e.	P	β	s.e.	P	B	s.e.	P	β	s.e.	P
Independent variables (HRV)	MeanRR	**0.033**	0.011	0.01	**0.032**	0.009	0.00	-0.08	0.053	0.16	**0.086**	0.042	0.04
	SDNNI	**0.202**	0.069	0.01	0.016	0.052	0.76	**0.814**	0.323	0.01	0.202	0.253	0.43
	HF (%)	0.200	0.138	0.15	**0.240**	0.104	0.03	**1.337**	0.646	0.04	0.024	0.506	0.96
	LF/HF	**2.723**	0.480	0.00	**1.442**	0.363	0.00	**6.259**	2.245	0.00	**3.966**	1.761	0.03

Notes: Significant values at p-value < 0.05 are denoted by bold formatting. β = Beta coefficient; s.e. = Standard error; P = p-value. For one unit increase in each sleep parameter, the percentage change in HRV is calculated as a reciprocal of beta coefficient value.

Based on the results in Table 7.2, the predictive ability to estimate the effect of work pressure on sleep quality was determined by considering only significant independents variables (i.e., Mean RR, SDNNI, and LF/HF) and training the data using the R software environment. The predictive HRV-Sleep score model was arrived at by training 80% of the datasets and using the remaining 20% to test the model. After training the data, it was deduced that the HRV data explained approximately 51% of the total variation in sleep score (see Table 7.3). Table 7.3 improves on the HRV-Sleep score model in Table 7.2. Thus, the final model indicates that with a 25.6 units increase in Mean R-R, 4 units increase in SDNNI, and 0.4 unit increase in LF/HF, sleep score increased by one unit, all things being held constant (see Table 7.3).

Hence, based on the result in Table 7.3, the HRV-Sleep quality predictive model becomes:

Sleep score = 20.65125 +0.039(Mean RR)+0.248(SDNNI)+2.479 (LF/HF) ……...(7.1)

Eqn. (7.1) is for determining the fit value, while considering a 95% confidence level, the upper and lower bound values of the model can be determined using Eqn. (7.2):

Upper or Lower limit: Sleep score = 20.65125 +0.039(Mean RR)+0.248(SDNNI)+2.479 (LF/HF) ± 4.90

…. (7.2)

Table 7. 3: Final model on the effect of work pressure on physiological health

Model	Sleep Score				
	Estimate	s.e	t-value	p-value	VIF
(Intercept)	20.65125	9.07191	2.276	0.02786*	
Mean RR	0.03925	0.01259	3.118	0.00325 **	2.512924
SDNNI	0.24802	0.07035	3.525	0.00102 **	2.035399
LF/HF	2.47886	0.39685	6.246	1.6e-07 ***	1.953078
Multiple R-squared	0.5402				
Adjusted R-squared	0.5081				
F-statistic	16.84			2.215e-07	
DF	3 and 43				

Notes: Significance codes: ‘***’ 0.001; ‘**’ 0.01; ‘*’ 0.05; s.e. = Standard error; P = p-value.
For one unit increase in sleep score, the percentage change in HRV is calculated as reciprocal of beta coefficient value.

7.3.3.1.1. Validating the predictive ability of sleep quality through HRV

The predictive ability of estimating the impact of work pressure on physiological health through the recovery path was cross-checked by validating the trained model. The trained model was validated using 95% confidence on a sample of HRV data (i.e., sdnni= 37.8302, meanrr= 760, lf/hf=0.988) using the command:

```
#predict model of sample data (default=95% confidence)
pred <- predict (Model, data.frame(sdnni= 37.8302, meanrr= 760, lf/hf=0.988),interval='confidence')
pred
plot(test$sleepscore,type ="l",lty = 1.8,col = "green")
```

> lines(pred,type = "l", col = "blue")

> #predict model of sample data (default=95% confidence)

> pred <- predict (Model, data.frame(sdnni= 37.8302, meanrr= 760, lf/hf=0.988),interval='confidence')

> pred

Fit	*lwr*	*upr*
62.31587	*57.61406*	*67.01768*……………………………………(7.3)

The command resulted in predicted sleep scores within three limits (fit, lower, and upper bound values) of approximately 58, 62, and 67, respectively, as shown in Eqn. (7.3). The predicted sleep score range falls within the poor and fair sleep range, as shown in Table 2.4. To further cross-validate the predictive ability of the model in Table 7.3, sleep data was collected with the activity tracker following the day's job. A total sleep time of 287mins (4hr 47mins) was deduced, with a sleep score of 67 (see Figure 7.2), which fits into the estimated range for sleep quality following day's stress shown in Eqn. (7.3).

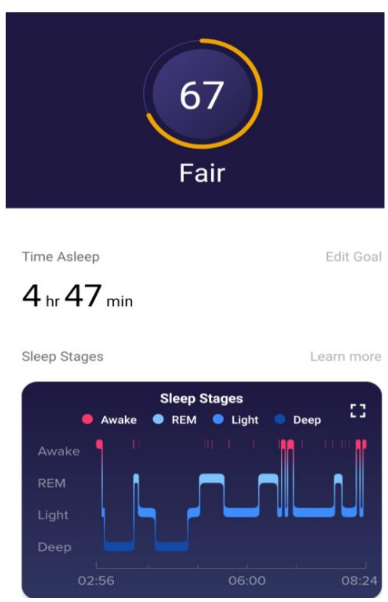

Figure 7. 2: Sample sleep score from Fitbit Alta HR

7.3.3.2. Determination of sleep quality based on subjective sleep data

Multiple regression analysis on sleep architecture and sleep score data revealed that only TST and WASO were significantly associated with sleep scores. Thereafter, in the R software, 80% of the total sleep dataset was used to create a TST-Sleep score predictive model that will aid the estimation of sleep quality from subjective sleep monitoring. In comparison, the remaining 20% of the dataset was used to test the model's accuracy. Based on the trained TST-Sleep score model, it was deduced that total sleep time (TST) accounted for 48% variation in the sleep score (see Table 7.4).

Table 7. 4: Model for estimating sleep score from subjective or objective sleep data

Model	Sleep Score			
	Estimate	Std. Error	t-value	p-value
(Intercept)	49.09990	4.82600	10.174	4.46e-11 ***
TST	0.06716	0.01253	5.359	9.36e-06 ***
Multiple R-squared	0.4976			
Adjusted R-squared	0.4802			
F-statistic	28.72			9.358e-06

Notes: Significance codes: '***' 0.001; s.e. = Standard error; P = p-value.

Therefore, to estimate sleep quality without the aid of an activity tracker, the TST-Sleep score predictive model outlined in Eqn. (7.4) can be employed.

Sleep score = 49.09990 + 0.06716TST ……………………………….............. (7.4)

Eqn. (7.4) is for determining the fit value, while considering a 95% confidence level, the upper and lower bound values of the model can be determined using Eqn. (7.5):

Upper or Lower limit: Sleep score = 49.09990 + 0.06716TST ± 3.2144 ……….. (7.5)

7.3.3.2.1. Validating of the predictive ability of TST- sleep quality model

The predictive ability of the trained TST- Sleep quality model was further validated by collecting data from three healthy participants and another activity tracker. The validation was carried out at 95% confidence on sleep data of TST=287 (see Figure 7.2) and using the R command. The command resulted in a sleep score within the lower, fit, and upper bound of 65, 68, and 71, respectively, as shown in eqn. (7.6). Figure 2 shows that the sleep score of 67 provided by the Fitbit app for a TST of 287mins (4hr47mins) fits appropriately into the range estimated by the TST-Sleep model.

```
> #predict model of sample data (default=95% confidence)
> pred <- predict (Model, data.frame(TST=287),interval='confidence')
> pred
Fit          lwr          upr
68.37397     65.14907     71.59888 ……………………………….. (7.6)
```

7.4 Discussion

This study outlines the impact of work pressure on physiological health and the importance of appropriate stress and sleep management in the construction industry. Overall, the participant groups were subjected to high work intensity beyond the allowable workload limit of 40%HRR employed by Hwang and Lee (2017). However, the tradesmen were subjected to more physical demand and elevated stress than the supervisors. The increase in physical demand and stress index among the tradesmen is not unlikely, as this group of participants engages in repetitive jobs involving climbing, lifting, and continuous hand movement (Hwang and Lee, 2017). There exists a conflicting allowable limit for %HRR sustained over an 8-hour workday. For instance, Norton et al. (2010) suggested 40 to 60%HRR daily aerobic activity, 30%HRR among teachers (Shimaoka et al., 1997), 24.5% among cyclists (Wu and Wang, 2002), and 30-40%HRR among construction tradesmen (Hwang and Lee, 2017).

With a significantly higher stress index among the tradesmen, unlike supervisors who were subjected to "normal" stress intensity, tradesmen were subjected to "elevated" stress intensity. Stress index characterizes the activity of the sympathetic part of the ANS and can better be applied to estimate not only the physical workload intensity but also emotional load (Quendler et al., 2017, Baevsky and Berseneva, 2008). Therefore, since there exists a statistically significant correlation between the stress index and %HRR, the result indicates that the uncertainty in the allowable limit for %HRR can be resolved by using the stress index to categorize the workload intensity. Considering that tradesmen were subjected to an elevated stress level, they had lower $HRV_{composite}$ than supervisors exposed to normal stress intensity. Thus, confirming the hypothesis ($H3_1$) that construction personnel with higher work pressure will have lower HRV. The lower $HRV_{composite}$ among tradesmen is evident by a higher sympathetic nervous system tone (LF power), higher sympathovagal balance (LF/HF), and lower parasympathetic nervous system tone (i.e., Mean R-R, SDNNI, SDNN, RMSSD, and HF power). This result is consistent with previous studies that deduced that heightened work stress is associated with reduced parasympathetic activation as sympathetic activity increases (Järvelin-Pasanen et al., 2018, Garza et al., 2015).

The LF/HF provides insight into the stress categorization of the participants' group. Viewing the LF/HF in 2D, as shown in Figure 1 and comparing it with the stress categorization recommended by von Rosenberg et al. (2017), tradesmen were subjected to higher physical demand and lower mental stress. On the other hand, the supervisors appear to be subjected to higher mental stress. This may have resulted from increased mental demand, which supervisors tend to be subjected to due to the total quality and project management nature of their job compared to tradesmen engaged in physical production. This result echoes the findings of Boschman et al. (2013), where supervisors were found to suffer more mental demand than bricklayers.

The TST recorded for both personnel categories ranged from 5.6 to 6.4 hours, with supervisors tending to sleep late and wake earlier, as revealed by the post-experiment interview; thus, they averaged 5.6 hours. The observed sleep duration among the participants was less than the recommended guideline of 8 hours per night for healthy adults, consistent with the findings of Powell and Copping (2010). The personnel appeared to have deep and REM sleep within allowable percentages but performed poorly in light sleep and WASO. There appeared to be no significant difference in sleep quality among the participants as both participant groups had sleep scores within the fair limit. Although tradesmen seem to have longer sleep duration following their day's work, they appeared to spend more time in the light sleep stage and less time in REM stage, resulting in lower sleep scores (i.e., sleep quality) than supervisors. This may have been a reaction to the elevated work stress they experienced, corroborating studies that associated more stage 1 sleep and less REM sleep with increased work stress (Ackermann et al., 2019, Âkerstedt, 2006).

To further explain the effect of work stress on health, the study determined the impact of HRV on sleep architecture and sleep quality. The study observed a significant positive association between sleep score and Mean R-R, SDNNI, and LF/HF. Thus, confirming the hypothesis ($H3_2$) that parasympathetic variables (Mean R-R, SDNNI) will positively relate sleep scores but negates the hypothesis ($H3_3$) that sympathetic variables (LF/HF) will negatively relate to sleep scores. This suggests that high HRV, indicated by increased Mean R-R or SDNNI, is related to increased sleep score. The result indicates that participants with lower HRV tend to have lower sleep quality, echoing the findings of Werner et al. (2015). This is because lower HRV during the day causes increased arousal that eventually impairs sleep quality and lowers the stress recovery process through sleep (Werner et al., 2015, Ackermann et al., 2019).

Considering the positive interaction between LF/HF and sleep score, this result showed that sleep score increased with an increased sympathovagal balance towards either a greater parasympathetic (HF) or sympathetic activity (LF). Thus, indicating that increased ANS due to increased work stress results in an increased need for recovery, which can be achieved through sleep. This supports the findings of Boschman et al. (2013), which pointed out the prevalence of the need for recovery among construction personnel. With a positive association between deep sleep, REM, SE, and HRV. This study found that similar to the sleep score, deep sleep, REM sleep, and SE reduced with low HRV and increased with high HRV. Also, the influence of LF/HF on deep sleep, REM sleep, and SE remained the same as for sleep score. Contrary to Werner et al. (2015), which opined that HRV is not related to sleep architecture parameters associated with cognitive processes necessary for good health, e.g., memory consolidation. This study shows that HRV influences sleep efficiency and sleep architecture parameters (particularly, deep sleep and REM).

LF/HF indicates the role of the activation of the sympathetic nervous system, which can be beneficial. However, excessive exposure to the situations that cause low HRV without proper rest could be detrimental to achieving proper recovery through sleep. Although the LF/HF indicates the need for recovery, expected to induce increased sleep duration and quality, exposure to work stress without increasing parasympathetic activity is disruptive to achieving recovery through sleep, thereby exposing the personnel to health risks. This also aligns with the findings of Åkerstedt et al. (2012), high work strain is associated with a 30% prevalence of disturbed sleep. The study showed that work pressure (HRV) among construction personnel induces the need for recovery and impair the ability to recover completely. Furthermore, this result indicates that while work offers access to the physical activity necessary to reduce ill-health risk factors, excessive stressful events can cause sympathetic overdrive of the autonomic nervous system, which may disrupt sleep (Garza et al., 2015, Norton et al., 2010, Kubala et al., 2020).

Sleep efficiency is an essential parameter in insomnia research, as it considers how long it takes to sleep after retiring to bed (Patel et al., 2018). With SE above 85% among all participants, the subjects did not appear to show any signs of insomnia. A sleep score estimation model was developed to aid the estimation of sleep scores in cases of subjective sleep measurement. The model deduced that while sleep architectures (i.e., stages) are determinants of sleep quality, TST is a major predictor. Thus, increasing sleep duration may afford the ability to spend more time in deep and REM sleep stages, which are important sleep stages in eliminating sleep debt (see Patel et al., 2018). Similar to Markov et al. (2016), in this study, BMI was not found to affect HRV parameters or sleep.

Both HRV and sleep predict cardiovascular functioning (Werner et al., 2015). Consequently, work stress and sleep quality share a causal and reverse causal relationship, where incomplete recovery can affect stress response and performance on a subsequent day. Thus, it is essential to keep stress within an acceptable stress intensity ranging between low to normal. This study indicates that construction personnel are exposed to high levels of work pressure evident by the decreased HRV. Decreased HRV signals a repeated excessive activation of the sympathetic nervous system, which may tax their hormonal and cardiovascular system, leading to endothelial dysfunction and increased risk of diseases (Garza et al., 2015). Therefore, with continued exposure to work-related stress, construction personnel are at risk of adverse health outcomes. This study draws attention to the need to consider sleep health interventions for proper work-stress recovery and demonstrates the possibility of using physiological indicators to evaluate recovery abilities.

7.5 Chapter Summary

The study investigated the impact of work stress (pressure) on physiological health. This study found that construction personnel are subjected to high work pressure evident by decreased HRV, thereby increasing their vulnerability to endothelial dysfunction and other adverse health outcomes. The study deduced that there appeared to be an intense need for recovery after work. However, the impact of the work stress altered the recovery process, evident by low sleep quality. This study provides additional information to existing studies by deducing that HRV during the day is related to some sleep architecture parameters (i.e., deep sleep and REM) associated with cognitive processes, e.g., memory consolidation, healing, and recovery that occurs during sleep. This study provides insight into sleep habits among construction personnel, causing supervisors to sleep late and wake early.

This study developed two predictive models that can be useful in stress and sleep health interventions. The first model (HRV-sleep score model) will help in estimating sleep quality from collected HRV. For instance, if the predicted sleep score is within a fair sleep quality. The information could help construction personnel become proactive in maintaining a healthier sleep habit after work necessary to boost the work-stress recovery process. The second model (TST-sleep score model) will be useful in sleep management, especially among persons who cannot afford an activity tracker. The TST-sleep score model will help personnel in estimating how well they slept a previous night by merely keeping track of their sleep and wake time. The information provided by the HRV-sleep score model and TST-sleep score model will impact individual and organizational practices and choices necessary to boost sleep health for proper cardiovascular and cognitive functioning.

On the individual level, it is necessary to sensitize construction personnel on the protective role of sleep quality in health and well-being, including cardiovascular functioning, thus the need to maintain healthy sleep habits. The workload should be designed to keep the daily stress intensity within normal levels on the organizational level. This study joins in emphasizing that the work-rest schedule suggested by previous research should be considered during the planning and scheduling of works. Organizations should encourage construction personnel to track their sleep during the week and weekends using wearable technologies, mobile apps, or a manual sleep log.

Finally, this study revealed that while daily work stress accounts for about half of sleep regulation, cognitive processes necessary for proper functioning, and good health, there are other factors, including individual practices, that inhibit optimal sleep health. Therefore, construction organizations need to develop and adopt sleep health interventions for proper work-stress recovery among their workforce. This study investigated the relationship between work stress as an important marker of health. Future studies should examine the bidirectional relationship between HRV and sleep. Such studies may benefit from recruiting male and female construction personnel with drinking and smoking lifestyle attitudes.

This study draws attention to the need to consider preventive interventions for proper work-stress recovery to ensure good health, safety compliance, and injury prevention among the workforce. Overall, using PPG-enabled wearables for health management may not be feasible, especially in low-income and developing countries; thus, the model can be developed into a simple mobile phone app that can be used to track recovery for health management. The research proposes an inexpensive means to estimate recovery possibilities, to track and self manage sleep health among construction personnel.

This chapter was used to achieve objective 2. It discussed the effect of work stress on psychophysiological health. This objective was achieved through an experimental procedure, and data were analyzed using multiple regression. Thereafter, two models were developed and validated. The succeeding chapter (Chapter 8) discusses objective three of the research study.

CHAPTER 8: IDENTIFICATION OF MULTI-LEVEL INTERVENTION STRATEGIES FOR A PSYCHOLOGICALLY HEALTHY CONSTRUCTION WORKPLACE IN NIGERIA[15]

8.1 Introduction

In the construction industry, to ensure the health and safety of on-site personnel, each project is bonded by legislation to have a health and safety manual and plan. The plan is preventive in form, detailing all health and safety risks, their sources, and outlines the best measures to prevent a casualty (Reis et al., 2015). Although the plan is expected to contain the medical examination of on-site personnel as a strategy for accident prevention, it does not detail measures to ensure good mental health among personnel. Like other countries, in Nigeria, the plan focuses on improving the physical working conditions for injury and accident prevention (see Dodo, 2014), without outlining strategies that can eliminate mental distress risk factors.

Consequently, the lack of strategic move to prioritize mental health and well-being of construction personnel by adopting measures to reduce work-related stress in Nigeria (see Ibem et al., 2011, Ojo et al., 2019), have resulted in reported feelings of depression, hopelessness, and anxiety (see Oladinrin et al., 2014). With increasing poor mental health among construction personnel, it will be expedient to ensure that the health and safety manual and plan detail workable strategies to be implemented on every construction project to promote mental health and well-

[15] This chapter is based on the article mentioned below produced by the author of the thesis during the PhD study: Nwaogu, J. M. and Chan, A. P. C. 2021a. Evaluation of multi-level intervention strategies for a psychologically healthy construction workplace in Nigeria. *Journal of Engineering, Design and Technology,* 19**,** 509-536. https://doi.org/10.1108/JEDT-05-2020-0159.

being. Ensuring good mental health and well-being holds the potential to reduce injury, near misses, and accident prevention (see Bryson and Duncan, 2018, Siu et al., 2004). For instance, it has been observed in a developed country like Australia that for every death lost to a fatal workplace accident construction industry, six are lost to suicide (Gullestrup, 2019).

In order to advance the health and safety research, the purpose of this study was to determine strategies to improve mental health in the construction industry of a developing country like Nigeria from the viewpoint of an integrated approach to mental health. This aim was achieved by adopting two objectives: (i) identify the strategies that can create a psychologically healthy and safe workplace; (ii) assess the criticality of the strategies on mental health using the fuzzy set theory. The knowledge of the strategies that hold the highest criticality will inform researchers about interventions to subject to further testing and their perceived strength in mitigating stress within the construction industry.

8.2 Research Design

This study was conducted to achieve objective three of the research. As described in Section 4.9, positivism philosophy was used to guide the study. Thus, the quantitative methodology, which involved a questionnaire survey, was adopted. The questionnaire was used to elicit experts' opinions from construction practitioners. Data were collected from 45 experts using the experts' questionnaire (see Appendix III) described in section 4.9.1.5. The data were analyzed using mean score, Kruskal-Wallis test, and fuzzy synthetic evaluation.

8.3 Results and discussion

8.3.1 Mean score ranking of the strategies

As shown in Table 8.1, celebrating employee success ranked the first strategy (mean = 3.64), followed by providing employees with competence training (mean = 3.64) among all the respondents. This is consistent with Pignata et al. (2017) that found celebrating success as a perceived strategy to reduce work-related stress. Likewise, Haynes and Love (2004) recommended that competence training is needed to help employees in the construction industry cope better with technological changes to eliminate mental ill-health risk factors such as fear of failure and job insecurity. However, the criticality of the strategies is determined by subjecting the result of the mean score to the Fuzzy Synthetic Evaluation (FSE).

8.3.2 Kruskal-Wallis Test

Kruskal-Wallis test was to determine whether the opinions on the strategies differed among the professional groups. As shown in Table 8.1, the ρ value of 26 strategies except for five strategies (ST11, ST12, ST8, ST10, ST15) was greater than 0.05, suggesting that there was no statistically significant difference in opinions for the 26 strategies. However, the difference in views for ST11, ST12, ST8, ST10, ST15 were statistically significant (i.e., ρ value less 0.05), meaning that the professionals differed in their opinion on the strategies.

Table 8. 1: Ranking of the strategies needed to make the construction workplace psychological safe and healthy

Code	All respondents			NIOB			NICE			NIQS			NIA			
	Mean	SD	Rank	Mean	SD	Rank	Mean	SD	Rank	Mean	SD	Rank	Mean	SD	Rank	ρ value
ST18	3.64	0.484	1	3.58	0.507	3	3.58	0.515	3	3.87	0.354	2	3.67	0.516	20	0.500
ST26	3.64	0.484	2	3.63	0.496	1	3.50	0.522	6	3.63	0.518	12	4.00	0.000	1	0.228
ST17	3.60	0.539	3	3.58	0.607	4	3.67	0.492	2	3.50	0.535	20	3.67	0.516	21	0.895
ST9	3.60	0.625	4	3.37	0.761	6	3.75	1.712	1	3.63	0.518	14	4.00	0.000	4	0.310
ST31	3.53	0.625	5	3.58	0.769	2	3.33	0.492	11	3.63	0.518	14	3.67	0.516	12	0.329
ST2	3.49	0.506	6	3.37	0.496	8	3.33	.492	20	3.75	0.463	5	3.83	0.408	11	0.068
ST1	3.49	0.549	7	3.32	0.582	10	3.50	0.522	6	3.75	0.463	9	3.67	0.516	18	0.243
ST28	3.49	0.695	8	3.26	0.872	17	3.50	0.522	5	3.75	0.463	3	3.83	0.408	9	0.243
ST11	**3.47**	**0.505**	**9**	**3.37**	**0.496**	**7**	**3.33**	**0.492**	**18**	**3.50**	**0.535**	**22**	**4.00**	**0.000**	**2**	**0.040**[a]
ST14	3.47	0.694	10	3.21	0.713	20	3.58	0.793	4	3.75	0.463	4	3.67	0.516	22	0.105
ST8	**3.44**	**0.659**	**11**	**3.32**	**0.820**	**14**	**3.17**	**0.389**	**23**	**3.75**	**0.463**	**8**	**4.00**	**0.000**	**5**	**0.008**[a]
ST24	3.44	0.725	12	3.26	0.933	15	3.42	0.515	8	3.75	0.463	6	3.67	0.516	17	0.395
ST4	3.42	0.499	13	3.53	0.513	5	3.25	0.452	21	3.25	0.463	30	3.67	0.516	24	0.200
ST7	3.42	0.583	14	3.32	0.671	12	3.33	0.492	19	3.63	0.518	15	3.67	0.516	23	0.414
ST19	3.42	0.621	15	3.32	0.749	11	3.42	0.515	10	3.63	0.518	13	3.50	0.548	25	0.746
ST21	3.42	0.657	16	3.26	0.733	16	3.42	0.669	9	3.88	0.354	1	3.33	0.516	27	0.112
ST16	3.40	0.580	17	3.32	0.478	9	3.33	0.651	13	3.38	0.744	27	3.83	0.408	6	0.226
ST27	3.40	0.654	18	3.26	0.806	18	3.33	0.492	16	3.63	0.518	11	3.67	0.516	15	0.414
ST23	3.38	0.650	19	3.21	0.713	19	3.33	0.651	17	3.62	0.518	18	3.67	0.516	19	0.293
ST25	3.36	0.645	20	3.16	0.688	24	3.33	0.651	12	3.62	0.518	17	3.67	0.516	16	0.185
ST5	3.33	0.739	21	3.16	0.898	23	3.25	0.622	22	3.50	0.535	24	3.83	0.408	10	0.217
ST10	**3.29**	**0.727**	**22**	**3.05**	**0.780**	**27**	**3.00**	**0.603**	**26**	**3.75**	**0.463**	**7**	**4.00**	**0.000**	**3**	**0.001**[a]
ST30	3.27	0.580	23	3.16	0.688	21	3.33	0.492	14	3.13	0.354	31	3.67	0.516	13	0.182
ST29	3.27	0.618	24	3.05	0.705	26	3.33	0.492	15	3.38	0.518	25	3.67	0.516	14	0.390
ST15	**3.24**	**0.645**	**25**	**3.11**	**0.658**	**25**	**3.08**	**0.669**	**24**	**3.38**	**0.518**	**28**	**3.83**	**0.408**	**7**	**0.043**[a]
ST20	3.24	0.802	26	3.32	0.820	13	2.92	0.900	28	3.50	0.756	19	3.33	0.516	28	0.390
ST6	3.22	0.599	27	3.16	0.501	22	3.08	0.669	25	3.50	0.535	23	3.33	0.816	29	0.406
ST3	3.18	0.747	28	3.00	0.816	29	3.00	0.739	27	3.63	0.518	16	3.50	0.548	26	0.119
ST12	**3.02**	**0.812**	**29**	**2.84**	**0.602**	**30**	**2.67**	**1.073**	**29**	**3.38**	**0.518**	**29**	**3.83**	**0.408**	**8**	**0.009**[a]
ST13	2.96	0.952	30	3.00	0.882	28	2.58	0.900	31	3.50	0.535	21	2.83	1.472	31	0.189
ST22	2.82	0.806	31	2.68	0.749	31	2.67	0.778	30	3.38	0.518	26	2.83	1.169	30	0.151

[a] The Kruskal-Wallis H test result is significant at the significance level of 0.05 (p-value < .05)

ST11 and ST12 are related to job redesign strategies, while ST8, ST10, ST15 are workplace justice focused. Likewise, in Sunindijo and Kamardeen (2017), work stressors causing workplace injustice (i.e., bullying, harassment, unequal policies) were statistically significant among the groups.

8.3.3 Fuzzy synthetic evaluation (FSE) technique

8.3.3.1 Build the principal factors/strategies

The 31 strategies were categorized into seven constructs following an exploratory factor analysis reported in another study using the developed questionnaire. The strategy constructs (STCs) are detailed in Table 8.2. The strategies are grouped into constructs as they serve two main functions in the FSE: (i) input variables necessary for the improvement of mental health in the workplace; (ii) determine the most critical strategy constructs that should be considered during the decision making.

8.3.3.2 Set up an assessment index system

From the seven constructs, an evaluation system needed to calculate the index was set up, with the STCs as the first level index system, represented as $v_{stc} = (v_{STC1}, v_{STC2}, v_{STC3}, v_{STC4}, v_{STC5}, v_{STC6}, v_{STC7})$ (Ameyaw and Chan, 2016, Owusu et al., 2019) and each individual strategies (STs) as the second level index system. The first and second system are the input variable for the FSE. The second level index system are represented as:

Table 8. 2: Mean score and Fuzzy Synthetic Evaluation Weightings of the Strategies

Code	Strategies (ST) and their Strategy Construct (STC)	Mean of ST	Total mean of STC	Weighing of STs w_{STi}	Weighing of STCs w_{STCi}	Level directed towards
	Stress control focused (STC1)					
ST31	Offer a sustainable retirement plan for employees	3.53		0.130		I
ST14	Put better education policies in place (e.g., subsidies for encouraging career development)	3.47		0.128		I
ST24	Conduct regular team meetings with personnel focused on addressing work stress	3.44		0.127		I
ST4	Promote mental health awareness through literacy programs	3.42		0.126		I
ST7	Provide practical stress management training	3.42		0.126		I
ST25	Promote communication about work stress without penalty	3.36		0.124		I
ST30	Provide aid for stressors such as financial challenges	3.27		0.120		I
ST29	Offer assistance to non-work stressors such as marital, family issues	3.27	27.18	0.120	0.260	I
	Healthy coping and individual resilience-focused (STC2)					
ST26	Provide employees with competence training	3.64		0.179		I
ST2	Introduce wellness programs to workplaces/site offices	3.49		0.171		I
ST1	Empower staff to be individually more resilient through resilience training	3.49		0.171		I
ST5	Stimulate helping behaviors towards people suffering from mental health problems through programs such as mental health first aid	3.33		0.164		I
ST6	Put measures in place for healthy exercise	3.22		0.158		I
ST3	Promote talks about anti-stigma (anti-stigma campaign)	3.18	20.35	0.156	0.195	I
	Job demand and satisfaction focused (STC3)					
ST21	Better planning of work tasks and shifts	3.42		0.262		I and O
ST20	Allow the taking of regular breaks to enable rest	3.42		0.262		I
ST23	Conduct employee satisfaction surveys	3.38		0.259		I and O
ST22	Hire more personnel to reduce the workload	2.82	13.04	0.259	0.125	I and O
	Employee morale and engagement-focused (STC4)					
ST18	Celebrate employee’s success	3.64		0.346		O
ST11	Promote employees’ deeply embedded life interest by designing job roles inline with employee’s deeply embedded interest	3.47		0.330		O
ST16	Give constructive feedbacks instead of reprimanding	3.40	10.51	0.324	0.101	O
	Workplace (organizational) justice-focused (STC5)					
ST9	Create policies to eliminate harassment	3.60		0.265		I and O
ST8	Create policies to eliminate bullying	3.44		0.254		I and O
ST10	Promote equality policies irrespective of gender, and age	3.29		0.242		I and O
ST15	Reduce threatening of staff with disengagement when they make mistakes	3.24	13.57	0.239	0.130	I and O
	Job redesign and control focused (STC6)					
ST19	Offer employee’s opportunities to balance work and life through compressed working week arrangement	3.42		0.364		O
ST12	Employees should be allowed some flexibility to design their job roles and tasks	3.02		0.321		O
ST13	The workplace should allow site employees’ to a flexible work schedule	2.96	9.40	0.315	0.090	O
	Interpersonal relationship-related (STC7)					
ST17	Ensure swift resolution	3.60		0.343		O
ST28	Put in place measures that increase cooperation between supervisors and subordinates	3.49		0.333		I and O
ST27	Supporting improved relationships at work	3.40	10.49	0.324	0.100	I and O
	Total		104.54		1.000	

Notes: I - Individual; O - Organization.

v_{STC1} = (v_{ST11} v_{ST12} v_{ST13} v_{ST14} v_{ST15} v_{STC16} v_{ST17} v_{ST18}); v_{STC2} = (v_{ST21} v_{ST22} v_{ST23} v_{ST24} v_{ST25} v_{ST26})

v_{STC3} = (v_{ST31} v_{ST32} v_{ST33} v_{ST34}); v_{STC4} = (v_{ST1} v_{ST42} v_{ST43}); v_{STC5} = (v_{ST51} v_{ST52} v_{ST53} v_{ST54})

v_{STC6} = (v_{ST61} v_{ST62} v_{STC63}}); v_{STC7} = (v_{ST71} v_{ST72} v_{STC73}).

8.3.3.3 Determine the membership grade of the variables ST and STC (first level)

In fuzzy set theory, the degree of membership within a given fuzzy set ranges between 0 and 1, describing the degree to which the element belongs to the fuzzy set (Owusu et al., 2019). Following Ameyaw and Chan (2016) and (Owusu et al., 2019), the linguistic term used to examine the input variables (i.e., strategies) against the criticality was determined using the 4-point rating system from very low (1) to very high (4) based on respondents' level of agreement with each strategy. The grading system for estimating the degree of probability of criticality based on the strategies is represented by V = (1,2,3,4), where v_1 = very low, v_2 = low, v_3 = high, v_4 = very high. Given this rating scale, the membership function of any given ST, $v_{STin,}$ is obtained using Eq. (8.1) below:

$$MF_{v_{STin}} = \frac{x_{1_{STin}}}{v_1}, \frac{x_{2_{STin}}}{v_2}, \frac{x_{3_{STin}}}{v_3}, \frac{x_{4_{STin}}}{v_4} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (8.1)$$

Where: n represent the nth strategy of a particular STC *i* (*i* = v_{STC1}, v_{STC2}, v_{STC3}, v_{STC4}, v_{STC5}, v_{STC6}, v_{STC7}); $x_{1_{STin}}/v_1$ is represented as a percentage, and $x_{j_{STin}}$ (*j* = 1,2,3,4). Therefore, upon substitution, the membership function for any given strategy (ST), will be written as given in Eq. (8.2):

$$MF_{v_{STin}} = (x_{1_{STin}}, x_{2_{STin}}, x_{3_{STin}}, x_{4_{STin}}) \quad \ldots\ldots\ldots\ldots\ldots\ldots (8.2)$$

As earlier stated, $MF_{v_{STin}}$ ranges between [0,1] and must sum up to one, indicating a unity. Therefore, $\sum_{j=1}^{4} x_{j_{STin}} = 1$ ……………………………………………….(8.3)

Hence, using ST30 as a typical example, based upon the ratings of the experts (i.e., 0.02%, 0.00%, 0.67%, 0.31%) and substituting into Eq. (8.1), we get:

$$MF_{ST30} = MF_{STC1_1} = \frac{0.02}{\text{very low}}, \frac{0.00}{\text{low}}, \frac{0.67}{\text{high}}, \frac{0.31}{\text{very high}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8.4)$$

The MF is thus, written in the form of Eq. (8.3) as $MF_{V_{STin}}$=(0.02, 0.00, 0.67,0.31). The remaining membership function for the STs was calculated in the same way, as shown in Eq. (8.2) and (8.3).

8.3.3.4 Calculate the weighing functions of the variables for the STs and STCs

The normalized mean method was used to derive the individual weighting of the variables within the strategy construct. Thus, the individual weighting of the ST and STC was gotten using the formulae as shown in (Owusu et al., 2019):

$$w_i = \frac{M_i}{\sum_{i=1}^{4} M_i}, \; 0<w_i<1, \text{ and } \sum_{i=1}^{n} w_i = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8.5)$$

Where, w_i is the weighting function of a strategy (ST) or strategy construct (STC) i; M_i represents the mean score of a specific ST or STC i derived from responses of the experts contained in Table 8.1. The set of weighting function is given as:

$$W_i = (w_1, w_2, w_3, \ldots\ldots\ldots\ldots w_n) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8.6)$$

Using ST30 as a typical example of how to determine the weightings of each strategy within a strategy construct, we consider substituting the mean values as appropriate into Eq. (8.5). It is important to note that ST30 is the same as $STC1_7$; upon applying Eq. (8.5), Eq. (8.7) is obtained:

$$w_{ST30} = w_{STC1_7} = \frac{3.27}{3.27+3.27+3.36+3.42+3.42+3.44+3.53+3.47} = \frac{3.27}{27.18} = 0.120 \quad \ldots\ldots\ldots\ldots\ldots\ldots(8.7)$$

The weightings of the remaining STs within each STCs are obtained by following the procedure described in Eq. (8.5) and (8.7) (see Table 8.3), can be put in the form of Eq. (8.6) and checked to ensure that $\sum_{i=1}^{n} w_i = 1$.

$W_{STC1_{1\text{-}8}} = (0.130, 0.128, 0.127, 0.126, 0.126, 0.124, 0.120, 0.120)$

$\sum_{i=1}^{8} w_i = 0.130+0.128+0.127+0.126+0.126+0.124+0.120+0.120 = 1.00$

Table 8. 3: Weightings and MF for the STs and STCs based on Fuzzy Synthetic Evaluation

Code	Weighing of STs	Weighing of STCs	MF of each ST at level 3	MF of each STCs at level 2	CL for STCs	MF of all STCs for level 1	Overall CL
						(0.02, 0.07, 0.48, 0.44)	3.36
STC1		0.260		(0.02, 0.02, 0.51, 0.46)	3.43		
ST31	0.130		(0.02, 0.00, 0.40, 0.58)				
ST14	0.128		(0.02, 0.04, 0.38, 0.56)				
ST24	0.127		(0.05, 0.00, 0.42, 0.53)				
ST4	0.126		(0.00, 0.00, 0.58, 0.42)				
ST7	0.126		(0.00, 0.04, 0.49, 0.47)				
ST25	0.124		(0.02, 0.02, 0.54, 0.42)				
ST30	0.120		(0.02, 0.00, 0.67, 0.31)				
ST29	0.120		(0.02, 0.02, 0.62, 0.34)				
STC2		0.195		(0.01, 0.05, 0.47, 0.47)	3.40		
ST26	0.179		(0.00, 0.00, 0.36, 0.64)				
ST2	0.171		(0.00, 0.00, 0.51, 0.49)				
ST1	0.171		(0.00, 0.02, 0.47, 0.51)				
ST5	0.164		(0.02, 0.09, 0.42, 0.47)				
ST6	0.158		(0.00, 0.09, 0.60, 0.31)				
ST3	0.156		(0.02, 0.13, 0.49, 0.36)				
STC3		0.125		(0.02, 0.12, 0.46, 0.40)	3.24		
ST21	0.262		(0.02, 0.02, 0.47, 0.49)				
ST20	0.262		(0.02, 0.16, 0.38, 0.44)				
ST23	0.259		(0.02, 0.02, 0.51, 0.45)				
ST22	0.259		(0.04, 0.29, 0.47, 0.20)				
STC4		0.101		(0.00, 0.01, 0.47, 0.52)	3.51		
ST18	0.346		(0.00, 0.00, 0.36, 0.64)				
ST11	0.330		(0.00, 0.00, 0.53, 0.47)				
ST16	0.324		(0.00, 0.04, 0.52, 0.44)				
STC5		0.130		(0.02, 0.16, 0.51, 0.31)	3.11		
ST9	0.265		(0.02, 0.47, 0.51, 0.00)				
ST8	0.254		(0.02, 0.02, 0.45, 0.51)				
ST10	0.242		(0.02, 0.09, 0.47, 0.42)				
ST15	0.239		(0.02, 0.05, 0.60, 0.33)				
STC6		0.090		(0.05, 0.12, 0.46, 0.37)	3.15		
ST19	0.364		(0.02, 0.00, 0.51, 0.47)				
ST12	0.321		(0.04, 0.18, 0.49, 0.29)				
ST13	0.315		(0.09, 0.20, 0.38, 0.33)				
STC7		0.100		(0.01, 0.03, 0.40, 0.56)	3.51		
ST17	0.343		(0.00, 0.02, 0.36, 0.62)				
ST28	0.333		(0.02, 0.04, 0.36, 0.58)				
ST27	0.324		(0.02, 0.02, 0.49, 0.47)				

ST = Strategies; STC = Strategy Construct; MF = membership function; CL = criticality level

Given that the summation of the mean values of all STCs (v_{STC1} = 27.18, v_{STC2} = 20.35, v_{STC3} = 13.04, v_{STC4} = 10.51, v_{STC5} = 13.57, v_{STC6} = 9.4, v_{STC7} = 10.49), is 104.54 (see Table 8.2). Thereafter, the mean of each STC *i* was normalized using Eq. (8.5) and (8.7).

$$w_{STC1} = \frac{27.18}{27.18+20.35+13.04+10.51+13.57+9.4+10.49} = \frac{27.18}{104.54} = 0.260$$

Similarly, $w_{STC2} = \frac{20.35}{27.18+20.35+13.04+10.51+13.57+9.4+10.49} = \frac{20.35}{104.54} = 0.195$

The same procedure was carried out to arrive at the weighing function of the remaining STCs (w_{STC3}=0.125, w_{STC4}=0.101, w_{STC5}= 0.130, w_{STC6}=0.090, w_{STC7}=0.100) (see Table 8.2). Also, the summation of all normalized weighing equals unity.

8.3.3.5 Building the multi-criteria and multi-level FSE model

This stage entails the determination of the STCs' criticality in making the construction workplace a psychologically healthy and safe place. Going by Eq. (8.2), the membership functions (MFs) of the STs under each STC can be written as given in Eq. (8.8), where the elements are represented by $x_{j_{STin}}$:

$$R_i = \begin{vmatrix} MF_{v_{i1}} \\ MF_{v_{i2}} \\ MF_{v_{i3}} \\ \cdots\cdots \\ MF_{v_{in}} \end{vmatrix} = \begin{vmatrix} x_{1_{v_{i1}}} & x_{2v_{i1}} & x_{3v_{i1}} & x_{4v_{i1}} \\ x_{1v_{i2}} & x_{2v_{i2}} & x_{3v_{i2}} & x_{4v_{i2}} \\ x_{1v_{i3}} & x_{2v_{i3}} & x_{3v_{i4}} & x_{4v_{i4}} \\ \cdots & \cdots & \cdots & \cdots \\ x_{1v_{in}} & x_{2v_{in}} & x_{3v_{in}} & x_{4v_{in}} \end{vmatrix} \qquad \cdots\cdots\cdots\cdots(8.8)$$

Using STC1 "stress control focused" in Table 8.2 as an example. In fuzzy matrix form, the elements are represented as shown in Eq. (8.8). Recall that $MF_{v_{STi1}} = MF_{STC1_7} = MF_{ST30}$, so we have:

$$R_i = \begin{vmatrix} MF_{ST31} \\ MF_{ST14} \\ MF_{ST24} \\ MF_{ST4} \\ MF_{ST7} \\ MF_{ST25} \\ MF_{ST30} \\ MF_{ST29} \end{vmatrix} = \begin{vmatrix} 0.02 & 0.00 & 0.40 & 0.58 \\ 0.02 & 0.04 & 0.38 & 0.56 \\ 0.05 & 0.00 & 0.42 & 0.53 \\ 0.00 & 0.04 & 0.58 & 0.42 \\ 0.00 & 0.00 & 0.49 & 0.47 \\ 0.02 & 0.02 & 0.54 & 0.42 \\ 0.02 & 0.00 & 0.67 & 0.31 \\ 0.02 & 0.02 & 0.62 & 0.34 \end{vmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8.9)$$

The FSE is made up of 3 levels of membership functions, starting from the third level to first level. The computations in this aspect are aimed toward achieving the second level of the FSE model. The fuzzy matrix is denoted by D_i and deduced by multiplying the weighing function set $W_i=\{w_1, w_2, w_3, \ldots\ldots\ldots.. w_n\}$ (see Eq. 8.6) of the STs within a STCs and the membership functions (obtained using Eq. 8.9) of the STs under each STC.

So, $D_i= W_i \bullet R_i$ ……………………………………………(8.10)

$$\left(d_{in},\ d_{in}, \ldots\ldots, d_{in}\right) = \left(w_{i1,} w_{i2,} \ldots\ldots..,w_{in}\right) \bullet \begin{vmatrix} MF_{v_{i1}} \\ MF_{v_{i2}} \\ MF_{v_{i3}} \\ \ldots\ldots \\ MF_{v_{in}} \end{vmatrix}$$

Equivalent to:

$$\left(d_{in},\ d_{in}, \ldots\ldots, d_{in}\right) = \left(w_{i1,} w_{i2,} \ldots\ldots..,w_{in}\right) \bullet \begin{vmatrix} x1_{v_{i1}} & x2_{v_{i1}} & x3_{v_{i1}} & x4_{v_{i1}} \\ x1_{v_{i2}} & x2_{v_{i2}} & x3_{v_{i2}} & x4_{v_{i2}} \\ x1_{v_{i3}} & x2_{v_{i3}} & x3_{v_{i4}} & x4_{v_{i4}} \\ \ldots & \ldots & \ldots & \ldots \\ x1_{v_{in}} & x2_{v_{in}} & x3_{v_{in}} & x4_{v_{in}} \end{vmatrix}$$

$= (d_{i1}, d_{i2}, d_{i3}, \ldots\ldots\ldots, d_{in})$ ………………………………………………(8.11)

$$D_{STC1} = (0.130, 0.128, 0.127, 0.126, 0.126, 0.124, 0.120, 0.120) * \begin{vmatrix} 0.02 & 0.00 & 0.40 & 0.58 \\ 0.02 & 0.04 & 0.38 & 0.56 \\ 0.05 & 0.00 & 0.42 & 0.53 \\ 0.00 & 0.04 & 0.58 & 0.42 \\ 0.00 & 0.00 & 0.49 & 0.47 \\ 0.02 & 0.02 & 0.54 & 0.42 \\ 0.02 & 0.00 & 0.67 & 0.31 \\ 0.02 & 0.02 & 0.62 & 0.34 \end{vmatrix}$$

$= (0.02, 0.02, 0.51, 0.46)$

Where d_{in} represent the grade alternative, V_i regarding a given STC i, and "•" is the fuzzy composition operation (Ameyaw and Chan, 2016).

Adopting the same approach, the membership function of the remaining STCs at the second level were derived (see Table 8.3). The next step is to determine the criticality level (CL) of each of the STCs. In order to achieve that, the formulae below (Eq. 8.12) is adopted:

$CL_i = \sum_{i=1}^{4} (D_{in} * V) = (d_{i1}, d_{i2}, d_{i3}, d_{i4}) * (1, 2, 3, 4)$ ………………………………(8.12)

where $1 \leq CL_i \leq 4$

Following eq. (8.11), the criticality index (CL) for each seven STCs is derived (see Table 8.3). The CL of STC1 to STC3 is worked as an example, as shown below:

$CL_{STC1} = (0.02, 0.02, 0.51, 0.46) * (1, 2, 3, 4)$

$= ((0.02*1)+(0.02*2)+(0.51*3)+(0.46*4))$

$CL_{STC1} = 3.43$ for the stress control-focused strategy.

$CL_{STC2} = (0.01, 0.05, 0.47, 0.47) * (1, 2, 3, 4)$

$CL_{STC2} = 3.40$ for healthy coping and individual resilience-focused strategy

$CL_{STC3} = (0.02, 0.12, 0.46\ 0.40) * (1, 2, 3, 4)$

$CL_{STC3} = 3.24$ for job demand and satisfaction focused strategy

8.3.3.6. Estimate the overall criticality index of the STCs

To arrive at the overall criticality index of the STCs, the weighted mean method was used for three reasons: (i) it reserves the performance effect of the strategies and their constructs, (ii) it has an upper limit of one as a result of the normalization of the weightings of the strategies and their constructs, (iii) wide use in fuzzy multi-criteria decision making evaluation (Ameyaw and

Chan, 2016, Owusu et al., 2019). Going by Owusu et al. (2019), the weighted mean method is derived using the formulae shown in Eq. 8.13:

$$d_{in} = \sum_{i=1}^{m} w_{in} x_{kv_{in}}, n = 1, 2, 3, \ldots, k) \ldots\ldots\ldots\ldots\ldots\ldots \quad (8.13)$$

The fuzzy matrix for $\bar{R}$, for evaluating the overall criticality level of the strategies in achieving a psychologically healthy and safe workplace is formed from the obtained evaluation matrixes, D_i(i=1, 2, 3, 4, 5, 6, 7):

$$\bar{R}_i = \begin{vmatrix} D_{STC1} \\ D_{STC2} \\ D_{STC3} \\ D_{STC4} \\ D_{STC5} \\ D_{STC6} \\ D_{STC7} \end{vmatrix} = \begin{vmatrix} d_{11} & d_{12} & d_{13} & d_{14} \\ d_{21} & d_{22} & d_{23} & d_{24} \\ d_{31} & d_{32} & d_{33} & d_{34} \\ d_{41} & d_{42} & d_{43} & d_{44} \\ d_{51} & d_{52} & d_{53} & d_{54} \\ d_{61} & d_{62} & d_{63} & d_{64} \\ d_{71} & d_{72} & d_{73} & d_{74} \end{vmatrix} \ldots\ldots\ldots\ldots\ldots\ldots \quad (8.14)$$

Where, D_{STC1} to D_{STC7} refers to the membership function of the STCs recorded at the second level (see Table 8.3).

To achieve the aim, $\bar{R}_i$ is then normalized using Eq. (8.10, 8.11), with the weighing function set of ($\bar{W}$= {w_i, w_2, w_3, w_4, }) for the STCs.

$\bar{D} = \bar{W}_i \bullet \bar{R}_i$

$$= (w_1, w_2, w_3, w_4, w_5, w_6, w_7) \bullet \begin{vmatrix} d_{11} & d_{12} & d_{13} & d_{14} \\ d_{21} & d_{22} & d_{23} & d_{24} \\ d_{31} & d_{32} & d_{33} & d_{34} \\ d_{41} & d_{42} & d_{43} & d_{44} \\ d_{51} & d_{52} & d_{53} & d_{54} \\ d_{61} & d_{62} & d_{63} & d_{64} \\ d_{71} & d_{72} & d_{73} & d_{74} \end{vmatrix} \ldots\ldots\ldots\ldots (8.15)$$

$\bar{D} = (\acute{D}_1, \acute{D}_2, \acute{D}_3, \acute{D}_4)$

Where, $\bar{D}_i$=($\acute{D}_1$, $\acute{D}_2$, $\acute{D}_3$, $\acute{D}_4$) is the membership function for all the strategies at the first level.

$$\overline{D} = (0.260, 0.195, 0.125, 0.101, 0.130, 0.090, 0.100) * \begin{vmatrix} 0.02 & 0.02 & 0.51 & 0.46 \\ 0.01 & 0.05 & 0.47 & 0.47 \\ 0.02 & 0.12 & 0.46 & 0.40 \\ 0.00 & 0.01 & 0.47 & 0.52 \\ 0.02 & 0.16 & 0.51 & 0.31 \\ 0.05 & 0.12 & 0.46 & 0.37 \\ 0.01 & 0.03 & 0.40 & 0.56 \end{vmatrix}$$

$\overline{D} = (0.02, 0.07, 0.48, 0.44)$

Finally, to derive the integrated criticality level of the strategies in creating a psychologically healthy and safe construction workplace (see Tables 8.3), we use Eq. (8.16) below:

$$CL_{overall} = \sum_{i=1}^{4} (\overline{D}_i * V) = (\acute{D}_1, \acute{D}_2, \acute{D}_3, \acute{D}_4)*(1, 2, 3, 4) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8.16)$$

where $1 \leq CL_i \leq 4$

$CL_{overall}=(0.02, 0.07, 0.48, 0.44)*(1, 2, 3, 4)$

$CL_{overall}=3.36$

The overall criticality level of the strategies based on the FSE technique is 3.36, implying that improving the psychological health of on-site construction personnel using these strategies is essential and holds promising results. As shown in Table 8.4, *employee morale and engagement-focused* strategies, and *interpersonal relationship-related* strategies are considered very important, with the highest index of 3.51. The indexes and ranking indicate the policies that need to be implemented or strengthened in making the construction workplace psychologically healthy and safe. Table 8.4 also shows the type of intervention strategy and level at which they are directed.

Table 8. 4: Criticality index of each STCs

Code	Strategies	Degree of Criticality		Intervention	
		Index	Linguistic	Type	Level directed towards
STC4	Employee morale and engagement-focused	3.51	Very high	Primary and Secondary	Organization
STC7	Interpersonal relationship-related	3.51	Very high	Primary and Secondary	Individual/Organization
STC1	Stress control focused	3.43	High	Secondary and Tertiary	Individual
STC2	Healthy coping and individual resilience-focused	3.40	High	Secondary	Individual
STC3	Job demand and satisfaction focused	3.24	High	Primary	Individual/Organization
STC6	Job redesign and control focused	3.15	High	Primary	Organization
STC5	Workplace (organizational) justice-focused	3.11	High	Primary	Individual/Organization
	Overall Criticality Level	3.36	High		

8.4. Discussion

8.4.1. Employee morale and engagement-focused strategies

With a criticality level of 3.51, this construct was deduced to be very critical to improving the psychological health of on-site construction personnel in Nigeria. The construct covers "*celebrating employees' success," "giving constructive feedbacks instead of reprimanding,"* and "*promoting employees' embedded life interest."* These strategies received a high mean score, resulting in the construct being the most important needed to be implemented to create a psychologically healthy and safe workplace. The construct consists of variables that can boost morale, increase job satisfaction and engagement level. For instance, *promoting embedded life interest* has been reported as an intrinsic motivator with the capacity to enhance the autonomy need of employees, increase job satisfaction, reduce job turnovers and increase performance

(VanAntwerp and Wilson, 2018). The strength of enhancing *deeply embedded life interests* lies in incorporating what an employee enjoys doing into his or her job role (VanAntwerp and Wilson, 2018). Considering that intrinsic motivators increase mental health and improve performance, to tap into the benefits of this strategy, the job roles of construction personnel can be reimagined.

As moves to boost the employee's morale and its related benefits, it is essential to enforce policies of *"giving constructive feedback to subordinates instead of reprimanding"* and *"celebrating employees' success."* Celebrating employees' success can take the form of recognition or intangible rewards such as appreciation from a supervisor, line manager, and colleagues (Pignata et al., 2017). The need to adopt these strategies is essential, considering the influence of generational gaps and motivation on the perception of stress. This finding is consistent with Bryson and Duncan (2018) and Pignata et al. (2017). As emphasized by Bryson and Duncan (2018), the way supervisors communicated feedbacks caused more stress to younger construction personnel resulting in increased absenteeism. Thus, subordinates require supervisors to express feedback in a supportive way free of reprimands.

8.4.2 Interpersonal relationship related

With a criticality index of 3.51, this construct ranks very high, as shown in Table 8.4. This construct corroborates earlier studies on the need to promote interpersonal relationships (Loudoun and Townsend, 2017, Brockman, 2014) by reinforcing specific strategies that are essential. The strategies include "*ensuring swift resolution*," "*increasing cooperation between supervisors and subordinates*," "*supporting improved relationships at work*" (see Table 8.2). For instance, Brockman (2014) asserted that ensuring swift conflict resolution in the construction industry offers some economic advantage over leaving conflicts unresolved or resolving them later. Strengthening interpersonal relationships in the workplace may offer therapeutic effects to improve health. Havermans et al. (2018) found that a supportive organizational culture that provides a feeling of unity reduces the stress level of employees. Similar to the findings of Migowski et al. (2018), in the construction industry, to effectively enhance interpersonal relationships, bottlenecks such as difficulty in information sharing, bureaucracy in workplace leadership, and unsupportive culture need to be eliminated.

8.4.3. Stress control focused

This construct is underlined by six strategies to reduce both work and non-work related stress and offer high criticality (see Table 8.4). The strategies are detailed in Table 8.2, ST14, ST29, ST30, and ST31 are employee assistance programs (EAPs); ST25, ST7, ST ST24 are related to stress management process, while ST4 relates to mental health literacy. This construct offers mental ill-health preventive and reactive ability. Effective implementation of EAPs has proved to be effective in cushioning the occurrence or effect of non-work related stress (Saju et al., 2019). Job insecurity, financial problems, inability to career development, low social-economic status, and marital challenges are identified risk factors for mental ill-health in the construction industry (Chan et al., 2020). Similarly, this study found that strategies to reduce the mentioned risk factors are expedient and corroborates with the recommendations of Chan et al. (2020) as well as Liang et al. (2018) on the need for detailed training on stress-coping.

Considering that construction companies are economically volatile as they depend on the availability of projects, modules on financial literacy should be incorporated into stress management training. In contrast, as regards financial needs, the aid provided can include offering financial credit and contingency contribution scheme (Richard, 2009). Additionally, due to the risk that comes with an improperly planned retirement, there is a need to enlighten employees on a variety of available retirement schemes to drive satisfaction benefits and productivity (Marcellus and Osadebe, 2014). Thus, echoing Horwitz et al. (2019), a sustainable retirement plan integrating financial psychology and employee engagement sponsored by the employer should be encouraged in the construction industry of Nigeria.

8.4.4 Healthy coping and individual resilience-focused

Strategies related to healthy coping and individual resilience ranked fourth, implying that the criticality level of the construct is high (see Table 8.4). Five strategies underline the construct (see Table 8.2). It is apparent that there is a need for secondary interventions to enhance mental health awareness, appropriate stress-coping, and resilience among personnel in the construction industry. This construct echoed Ajayi et al. (2019) and Bryson and Duncan (2018), positing the need to curb stigma to prevent mental ill-health in the construction workplace. The fear of stigma, lack of support from supervisors and colleagues in the working population decreases appropriate help-seeking among persons experiencing mental health problems (Havermans et al., 2018, Moll, 2014, Bryson and Duncan, 2018). Promoting anti-stigma and stimulating helping behaviors towards people suffering from mental health problems are strategies proven to mitigate mental ill-health among the working population (Bryson and Duncan, 2018).

Individual resilience negatively impacts psychological stress among construction personnel (Chen et al., 2017b). The chances of developing mental health problems are dependent on the level of an individual's resilience (Black et al., 2017, Horn et al., 2016). Interestingly, resilience can be acquired through resilience training (Burke, 2019), with benefits such as cognitive coping skills, enhancing appropriate lifestyle modifications, and reduction of burnout (Chen et al., 2017b). Thus, in the construction industry of Nigeria, enhancing resilience among personnel will be a good target for indicated interventions. Enhancing individual resilience in the workplace can be achieved through a number of interventions, namely cognitive-behavioral therapy, workplace coaching, and workplace physical activity (Glozier and Brain and Mind Centre, 2017).

While physical activity forms part of a wellness program, it is more than just fitness (Brown et al., 2011); it can take several forms of activities to enhance personal effectiveness, improve the quality of life, and organizational productivity. Considering the health and well-being challenges in the construction workplace (Lingard and Turner, 2017, Nwaogu et al., 2019b, Chung et al., 2018), wellness programs which may benefit the industry include physical activity and nutrition, cardiovascular health components, a-day walking activity, repetitive stress-injury prevention program, and tobacco-free workplace (see Berry et al., 2011).

As regards *providing competence training*, Havermans et al. (2018) deduced competence training as a viable way for employees to cope with stress, set boundaries, and deal with changes. When considering the increase in the application of technology in the construction industry, appropriate competence training is needed to help personnel cope with changes and trends in technological applications relevant to their jobs (Ganah and John, 2015), such as the use of 5D to 8D Building Information Modelling, unmanned aerial system (UAS), industrialized building components and safety instruction systems.

8.4.5 Job demand and satisfaction focused

This construct was identified to be critical in making the construction workplace in Nigeria psychologically healthy and safe (see Table 8.4). It is underlined by four strategies, namely *better planning of work tasks and shifts, allow regular breaks for rest, hire more personnel to reduce the workload*, and *conduct employee satisfaction surveys*. The strategies in this component are mainly secondary interventions that can be directed to the individual level for work stress prevention. This finding echoed Havermans et al. (2018), on the need of organizational measures that allow better planning of work tasks, and hiring of more personnel. Furthermore, organizations should undertake regular employee satisfaction surveys to identify areas of improvement and development (Havermans et al. 2018).

In the construction industry, high job demand arising from work pressure, working in excess of 85 hours per week, budget-related deadlines, high volume of work due to staff shortage and work contact (working outside working hours) are identified risk factors for mental health problems (see Boschman et al., 2013, Ibem et al., 2011, Oladinrin et al., 2014, Sunindijo and Kamardeen, 2017, Bowen et al., 2018). Therefore, implementing the strategies in this construct could help mitigate job demand related risk factors in the construction workplace.

8.4.6 Job redesign and control focused

Job redesign and control related strategies ranked sixth in criticality (see Table 8.4). The strategies in this construct offer opportunity for redesigning jobs in the construction workplace. They include *flexible work schedules, flexibility to design job roles and tasks (ST12),* and *work* *and life balance through compressed working week arrangements (see Table 8.2)*. Construction personnel have yearned for the possibility of adopting flexible work arrangements in the industry (Ajayi et al., 2019, Ojo et al., 2019). As means to achieve job satisfaction and good mental health in the technological age, there is a need to consider adopting flexible work arrangements (FWA) such as a result-only work environment, flexi-term contract, self-scheduling and flexitime intervention among construction industry personnel (Nwaogu et al., 2019b). This arrangement can provide employees with a sense of job control, especially in those FWA that provide employees with the opportunity to determine their work schedule, such as self-scheduling (Joyce et al., 2010).

Compressed working week (CWW), a type of FWA involves an increase in the hours worked per day while reducing the number of days worked to five days (Joyce et al., 2010, Lingard et al., 2007). The CWW affords employees an improved work-life balance (Joyce et al., 2010, Lingard et al., 2007). Improving work-life balance can reduce adverse health or organizational effects arising from high job demand and work-life imbalance (Joyce et al., 2010). In implementing CWW, weekend work hours can be eliminated by changing from a 9-hour Mondays to Fridays work schedule obtainable in the Nigerian construction industry to a 10-hour schedule. Adopting these forms of FWA could help increase job satisfaction, improve mental health, reduce worker's compensation claims, and increase productivity for construction organizations.

Strategy ST12 is known as job crafting and characteristic of increasing the perception of job control among employees. In job crafting, employees are allowed to make changes to their tasks and relationships without jeopardizing productivity, allowing them to create significance from their job (Burke, 2019, Wrzesniewski and Dutton, 2001). Redesigning jobs by adopting job crafting will help improve job satisfaction, engagement, individual resilience, and thriving (Burke, 2019). In an effort to make the workplace psychologically healthy and safe while improving job control, jobs in the construction workplace can be redesigned by implementing the strategies in this construct.

8.4.7 Workplace (organizational) justice-focused

This construct consists of four strategies aimed at eliminating organizational injustice in the construction workplace. They include *policies to eliminate bullying, harassment, reduce threatening of staff with disengagement when they make mistakes and promoting equality irrespective of gender and age* (see Table 8.2). The strategies in this component are mainly secondary interventions. Measures of workplace injustice such as bullying, harassment, gender and age discrimination, have been reported as mental ill-health risk factors in the construction workplace (see Bowen et al., 2014b, Kamardeen and Sunindijo, 2017, Sunindijo and Kamardeen, 2017, Chan et al., 2020). Therefore, necessitating the need for measures to eliminate workplace injustice. This calls for implementing or strengthening policies in the construction workplace that will promote organizational justice and related benefits such as fostering job satisfaction, reduction in burnout and sleep problems (Topbaş et al., 2019; Gluschkoff et al., 2017).

Finally, threatening staff with disengagement when they make mistakes predicts job insecurity and poor mental health (Shin and Hur, 2019). Thus, ensuring organizational justice through promoting civility can act as a resource in the construction workplace to improve mental health and well-being.

8.5 Chapter Summary

This study examined strategies that need to be implemented within the Nigerian construction workplace to improve the mental health of on-site personnel. In the study, 31 intervention strategies relevant to eliminating stress and promoting good mental health were identified from occupational health literature and subjected to expert ratings. The strategies were grouped into seven major groups following an exploratory factor analysis. The subjective responses were objectified using FSE. This study serves as an initial screening of the most critical strategies to achieve good mental health among construction personnel.

This study revealed that *employee morale and engagement-focused* and *interpersonal relationship-focused strategies* offer better criticality in enhancing good mental health and well-being in the construction industry of Nigeria. This study provides two significant contributions to the body of knowledge in the global construction industry. Firstly, providing a list of multi-level intervention strategies that can be explored in the construction workplace to make it psychologically healthy and safe. Secondly, it provides decision-makers in the construction industry with practical approaches to adapt and reinforce in the industry to improve personnel's mental health.

Considering that the construction industry is a major source of employment and gross domestic product to any nation, putting measures in place to improve the mental health of construction personnel becomes a priority with promising benefits to both employees, employers, and society. The benefits include good mental health and well-being, increased job performance on the individual level; reduced compensation claims, and increased productivity on the organization level.

This chapter was used to achieve the identification aspect of objective 3. It discussed the intervention strategies needed for improving mental health in the construction industry of Nigeria. The strategies are further evaluated in the succeeding chapter (Chapter 9). Data was collected from experts since they occupy decision-making positions in the industry and will be saddled with the feasibility and implementation of the research findings. The data collected was analyzed using the fuzzy synthetic technique. The succeeding chapter (Chapter 9) also discusses objective four of the research study.

CHAPTER 9: EVALUATION OF MENTAL HEALTH INTERVENTION STRATEGIES

9.1 Introduction

Based on the magnitude of productivity lost to mental ill-health symptoms, it will be expected that employers invest in mental health intervention programs. To underscore the problem of mental ill-health, it has been recommended that organizations should establish a healthy culture that prevents work-related stress and aid mental ill-health identification and treatment (Goetzel et al., 2018). Some solutions (mostly single-leveled) that form the basis of interventions have been proposed within the construction industry. The solutions include primary interventions, e.g., such as a compressed workweek, 450 minutes workday per week (Yip and Rowlinson, 2009, Lingard et al., 2007), and secondary interventions (e.g., those to build individual coping strategies). Evidence shows that sustainable interventions for mental health should be multimodal interventions to mitigate risk factors present at that individual and organization level.

Unlike single-level interventions, multimodal interventions offer mental health promotion within an integrated approach. Therefore, to build a workplace where the productivity and wellbeing of personnel are maintained and employees are satisfied, a mix of measures that satisfy an integrated approach to mental health should form the basis of policymaking. Therefore, a system-based approach is recommended to advance the understanding of the impact of multimodal intervention strategies on mitigating and eliminating mental ill-health among construction supervisors. The system-based approach entails using a system dynamics model to simulate and reinforce the impact of implementing multimodal intervention strategies on long-term stress and mental health-related outcomes in the construction workplace.

Therefore, this study attempts to evaluate the intervention strategies and create awareness of the strategies that could be implemented to alleviate work stress and improve construction personnel' mental health in Nigeria. The objectives to achieve the aim are (i) to identify intervention strategies perceived by supervisors to be most important; (ii) quantify the impact of stressors, individual protective factors, and job intervention strategies on mental health; and (iii) demonstrate the essence of engaging multimodal intervention strategies and their priority. The objectives were further achieved by testing the hypothesis stated in Section 2.11. The study underscores the importance of multimodal interventions in the construction workplace. This study expands the existing knowledge on the state of mental health among construction professionals and intervention strategies that could become the basis of policymaking in the construction industry. Although this study focused on construction supervisors within Nigeria's context, the findings from the study provide some applicability to the construction industry of other countries.

9.2 Research Design

This study was conducted to achieve objective four of the research. Majority of the results, except for the supervisors’ perception on intervention strategies, have been discussed in previous sections. The intervention data collected was analyzed using mean score. In order to quantify the impact of risk factors, individual protective factors, and job intervention strategies on mental health, the data were analyzed using structural equation modeling. The odds ratio for developing a mental ill-health symptom or not were inputted for the system dynamics modeling analyzed used for the analysis. The intervention data collected was analyzed using mean score, univariate logistic regression analysis, and system dynamics modeling (SDM). The SDM was performed in Vensim PLE software for Microsoft (version 8.2); the mean and logistic regression were performed using Statistical Package for Social Sciences (SPSS) version 26.0. The structural equation modeling was performed using the SmartPLS 3.3.3 software.

9.3 Results

At the end of the data collection period, out of 550 questionnaires administered, a total of 174 filled questionnaires were retrieved, representing a 34.8% response rate. Aligning with the nature of the construction industry, the respondents were predominantly male (90.8%), while only 9.2% were females (see Table 9.1). The supervisors' nomenclature included site engineer/supervisors, project manager and their assistants, 73.6% of the respondents had over six years of work experience. Given the respondents' demographic characteristics, all the supervisors were fit to provide credible information.

Table 9. 1: Demographic and mental ill-health characteristics of the construction supervisors

Variable	Categories	Frequency (%)
Demographics characteristics		
Sex	Male	158 (90.8)
	Female	16 (9.2)
Mental ill-health symptoms		
Depression (0, 27)	None-Minimal (0-4)	79 (45.4)
	Mild (5-9)	65 (37.4)
	Moderate (10-14)	27 (15.5)
	Moderately severe (15-19)	3 (1.7)
Anxiety (0, 6)	None-minimal (0-2)	149 (85.6)
	Mild-moderate (≥ 3)	25 (14.4)

9.3.1 Risk factors of mental ill-health symptoms among supervisors

Logistic regression revealed that only 25 out of 38 stressors were risk factors of mental ill-health among the respondents (see Table 9.2). Specifically, the 25 stressors were associated with the likelihood of developing depression. In contrast, only two of the stressors (i.e., occupational injury/hazard and poor extended family relationship) were related to anxiety symptoms. The odds ratios of developing depression or anxiety ranged from 1.03 to 4.96 for *bullying* and *low social support from colleagues and supervisors*, respectively, among those exposed to the stressors.

9.3.2 Intervention strategies to improve mental health

The RII of the intervention strategies showed that the majority (29/30) of the strategies ranked within the high importance range of 0.8-1.0 (see Table 9.3). Notably, "*ensuring a sustainable retirement plan for employees*," "*celebrate employee's success*," and "*reduce the threatening of staff with disengagement*" ranked as the top three strategies necessary to promote a Nigerian construction workplace that is psychologically healthy. Overall, the *interpersonal relationship construct* ranked the highest (mean = 3.48), followed by *employee morale and engagement-focused construct* (mean = 3.43).

Table 9. 2: Mental ill-health risk factors and their constructs

Code	Variables	Univariate Logistic Regression			
		Depression		Anxiety	
		p-value	OR	OR	p-value
Job demand related					
CS04	Workload	**0.002**	**4.26**	0.998	33.00
CS05	Increased work speed	**0.009**	**3.77**	0.191	3.94
CS12	Strict adherence to time or schedule	**0.002**	**3.18**	0.986	1.01
CS02	Nature of work causing increased mental demand	**0.000**	**3.94**	0.089	2.98
CS03	Hours worked per day	0.383	1.36	0.681	0.82
Job support related					
CS07	Little social support from colleagues and supervisors	**0.000**	**4.96**	0.255	2.09
CS08	Little relationship with colleagues and supervisors	**0.000**	**4.03**	0.064	3.28
CS14	Criticisms from superiors	0.052	1.93	0.053	1.37
CS15	Lack of feedback mechanism in place	0.569	1.22	0.904	0.94
CS20	Interpersonal conflict at work	0.093	1.68	0.972	0.99
Job control related					
CS06	Little opportunity to participate in decision making	**0.000**	**4.93**	0.080	3.80
CS18	Little task authority	**0.009**	**2.40**	0.099	2.57
		0.240	1.43	0.084	2.21
Welfare related					
CS11	Job insecurity	**0.002**	**3.39**	0.088	3.66
CS10	Lack of leave or housing allowance	**0.015**	**2.53**	0.423	0.68
CS34	Lack of subsidies for family travel fees in the case of a transfer	**0.002**	**2.83**	0.910	0.95
CS33	Lack of a medical plan for employees	**0.000**	**4.04**	0.204	1.96
CS16	Low socio-economic status	**0.001**	**3.07**	0.274	1.79
CS32	Under promotion	**0.000**	**3.61**	0.216	1.85
CS29	Unsatisfactory living condition at home	**0.000**	**3.84**	0.450	1.46
CS19	Fear of failure at the job	**0.004**	**2.48**	0.183	0.56
CS17	Over promotion	**0.039**	**1.89**	0.256	0.60
CS27	Low income causing financial insecurity	0.068	2.48	0.557	1.58
CS28	Salaries not paid on time	0.924	1.03	0.774	0.88
CS35	Lack of opportunity for career development	0.053	1.94	0.349	0.65
CS36	Lack of opportunity for promotion	0.116	1.75	0.281	1.86
CS37	Lack of team or departmental or company social get-togethers	0.101	1.72	0.379	1.55
Work hazard-related					
CS13	Fatigue resulting from work causing poor sleep and recovery	**0.003**	**3.49**	0.070	6.56
CS01	Physical illness arising from work pressure	**0.001**	**3.27**	0.231	1.99
CS21	Musculoskeletal pain and injuries	**0.004**	**2.47**	0.477	1.38
CS09	Occupational injury/hazard	**0.000**	**3.36**	**0.029**	**2.96**
CS22	Poor physical working condition	0.523	1.22	0.510	1.35
Family-related					
CS26	Work-home/life imbalance	**0.000**	**3.40**	0.773	1.15
CS31	Poor family connection or relationships	**0.012**	**2.19**	**0.014**	**3.35**
CS30	Marital relationship and challenges	**0.006**	**2.40**	0.163	1.84
Workplace injustice related					
CS25	Workplace bullying	**0.048**	**1.03**	0.334	1.52
CS24	Workplace harassment	0.608	0.86	0.406	1.44
CS23	Lack of respect from subordinates	0.240	1.43	0.084	2.21

Note: Figures in bold are significant; OR – Odds Ratio

Table 9. 3: Intervention strategies to implement for mental health promotion

Code	Strategies	Descriptive Statistics				
		RII	Mean	SD	R	TOI
Interpersonal relationship-related (SC1))			**3.48**			P, S
ST16	Ensure swift conflict resolution	0.88	3.53	0.61	5	
ST26	Supporting improved relationships at work	0.86	3.45	0.59	8	
ST27	Put in place measures that increase cooperation between supervisors and subordinates	0.86	3.45	0.67	9	
Employee morale and engagement-focused (SC2)			**3.43**			P, S
ST17	Celebrate employee's success	0.89	3.57	0.67	2	
ST15	Give constructive feedback instead of reprimanding	0.86	3.44	0.62	10	
ST10	Promote employees' deeply embedded life interest by designing job roles in-line with embedded interest	0.82	3.29	0.77	25	
Healthy coping and individual resilience-focused (SC3)			**3.42**			S
ST25	Provide employees with competence training	0.89	3.54	0.59	4	
ST13	Put better education policies in place (e.g., providing subsidies for / encouraging employee career development	0.87	3.49	0.63	6	
ST4	Promote mental health awareness through literacy programs	0.85	3.41	0.76	11	
ST2	Introduce wellness programs to workplaces/site offices, including measures in place for exercises such as exercise weekends or challenge or going for walks	0.85	3.39	0.66	13	
ST1	Empower staff to be individually more resilient through resilience training programs	0.84	3.35	0.75	18	
ST6	Provide practical stress management training	0.83	3.31	0.78	23	
Workplace (organizational) justice-focused (SC4)			**3.40**			P
ST14	Reduce threatening of staff with disengagement when they make mistakes	0.89	3.55	0.64	3	
ST8	Create policies to eliminate harassment	0.85	3.39	0.80	15	
ST7	Create policies to eliminate bullying	0.83	3.34	0.74	20	
ST9	Promote equality policies irrespective of gender, and age	0.81	3.32	0.80	22	
Job demand and satisfaction focused (SC5)			**3.35**			P
ST20	Better planning of work tasks and shifts	0.85	3.41	0.81	12	
ST22	Conduct employee satisfaction surveys	0.84	3.38	0.73	16	
ST19	Allow the taking of regular breaks to enable rest	0.84	3.34	0.69	19	
ST21	Hire more personnel to reduce the workload	0.81	3.25	0.78	28	
Employee Assistance Programme (SC6)			**3.34**			S, T
ST30	Offer a sustainable retirement plan for employees	0.91	3.63	0.62	1	
ST23	Conduct regular team meetings with supervisors and tradesmen focused on addressing work stress	0.85	3.39	0.69	14	
ST24	Promote communication about work stress from supervisors or tradesmen without penalty	0.82	3.29	0.67	24	
ST29	Provide aid for stressors such as financial challenges	0.81	3.25	0.66	27	
ST28	Offer assistance to nonwork stressors such as marital, family, or relationship challenges or lifestyle challenges	0.78	3.14	0.67	30	
Job redesign and control focused (SC7)			**3.33**			P
ST18	Offer employee's opportunities to balance work and life using a compressed workweek	0.87	3.48	0.70	7	
ST12	The workplace should allow site employees' a flexible work schedule with regards to work time and duration with no intention to reduce productivity or performance	0.82	3.29	0.83	26	
ST11	Employees should be allowed some flexibility to design their job roles and tasks while human resources approve it in-line with the job position and goals of the organization	0.81	3.22	0.79	29	

Note: The strategies are adapted from Nwaogu and Chan (2021a); RII – Relative Importance Index; Figures in bold are the mean score for the construct; SD - Standard Deviation; TOI – Type of Intervention; R – Rank; P – Primary; S – Secondary; T – Tertiary intervention

9.3.3 Structural equation modelling

9.3.3.1 Evaluation of the model measurements

After eliminating all strategies and stressors with factor loading below the threshold of 0.5, only 24 intervention strategies and 18 stressors were fit for the analysis. As shown in Table 9.4, the constructs had Rho_A and composite reliability scores above 0.70 and AVE above 0.50, indicating appropriate construct reliability and validity. With the HTMT of the constructs being below 0.80, the constructs had acceptable discriminant validity (see Table 9.5). Although the strategies retained were related to the seven strategy constructs outlined in Table 9.3, only stressors related to welfare and socio-economic conditions, job demand, work hazard, and family were retained in the model.

Table 9. 4: Measurement model evaluation

Second-order constructs	First-order constructs	Indicators	Loading	Composite Reliability	Rho_A	AVE
Mental Health Outcome	Anxiety VIF = 1.453	b10_Anxiety b11_Anxiety	0.877 0.883	0.873	0.709	0.709
	Depression VIF = 1.846	b2_Depress b3_Depress b4_Depress b6_Depress b7_Depress b8_Depress b9_Depress	0.702 0.571 0.583 0.642 0.625 0.565 0.574	0.805	0.721	0.400
Protective Factors **VIF = 1.236**	Emotion Focused VIF = 1.256	dCP26	1	1	1	1
	Problem Focused VIF = 1.628	dCP1 dCP2 dCP3 dCP4 dCP6 dCP8	0.715 0.745 0.83 0.738 0.699 0.596	0.867	0.826	0.524

Note: Indicators with loadings below 0.5 were removed. AVE = Average Variance Extracted; Values in italics are higher-order construct (i.e., second-order construct).

Table 9.4 (continued): Measurement model evaluation

Second-order constructs	First-order constructs	Indicators	Loading	Composite Reliability	Rho_A	AVE
Protective Factors	Individual Resilience (IR)	R1	0.908	0.905	0.791	0.827
	VIF = 1.357	R2	0.911			
Risk Factors VIF = 1.021	Job Demand (D-R)	CS4_JD	0.888	0.907	0.896	0.501
	VIF = 1.350	CS12_JD	0.794			
	Work Hazard (WH-R)	CS13_WH	0.746			
	VIF = 1.500	CS21_WH	0.826			
		CS22_WH	0.806			
	Family (F-R)	CS26_F	0.751			
	VIF = 1.533	CS30_F	0.817			
		CS31_F	0.804			
	Welfare and socio-economic (WS-R)	CS10_WS	0.533			
	VIF = 1.844	CS11_WS	0.552			
		CS27_WS	0.668			
		CS29_WS	0.721			
		CS32_WS	0.726			
		CS33_WS	0.79			
		CS34_WS	0.682			
		CS35_WS	0.72			
		CS36_WS	0.794			
		CS37_WS	0.59			
Job resources VIF = 1.255	HCIR-S	PSHW4	0.782	0.946	0.924	0.523
	VIF = 3.176	PSHW5	0.749			
		PSHW6	0.807			
		PSHW13	0.775			
		PSHW26	0.737			
	EM-S	PSHW10	0.775			
	VIF = 3.501	PSHW16	0.846			
		PSHW18	0.82			
	JRC-S	PSHW11	0.838			
	VIF = 3.261	PSHW12	0.739			
		PSHW19	0.754			
	WJ-S	PSHW15	0.763			
	VIF = 2.381					
	IR-S	PSHW17	0.775			
	VIF = 2.792	PSHW27	0.854			
		PSHW28	0.867			
	JD-S	PSHW20	0.758			
	VIF = 2.684	PSHW21	0.752			
		PSHW22	0.812			
		PSHW23	0.834			
	EAP-S	PSHW24	0.709			
	VIF = 2.187	PSHW25	0.747			
		PSHW29	0.781			
		PSHW30	0.795			
		PSHW31	0.716			

Note: EM-S = Employee morale and engagement strategies; HCIR-S = Healthy coping and individual resilience; IR-S = Interpersonal relationship; JD-S = Job demand and satisfaction strategies; EAP-S = Employee Assistance Programme strategies; WJ-S = Workplace (organizational) justice-focused strategies; JRC-S = Job redesign and control strategies.

Table 9. 5: Discriminant Validity (HTMT Criterion)

	EM-S	HCIR-S	IR-S	JDS-S	JRC-S	SC-S	Stressors	WJ-S
EM-S								
HCIR-S	0.662							
IR-S	0.476	0.502						
JDS-S	0.792	0.568	0.578					
JRC-S	0.819	0.430	0.447	0.7				
SC-S	0.799	0.758	0.469	0.679	0.676			
Stressors	0.236	0.233	0.11	0.168	0.197	0.137		
WJ-S	0.827	0.552	0.378	0.555	0.741	0.543	0.212	

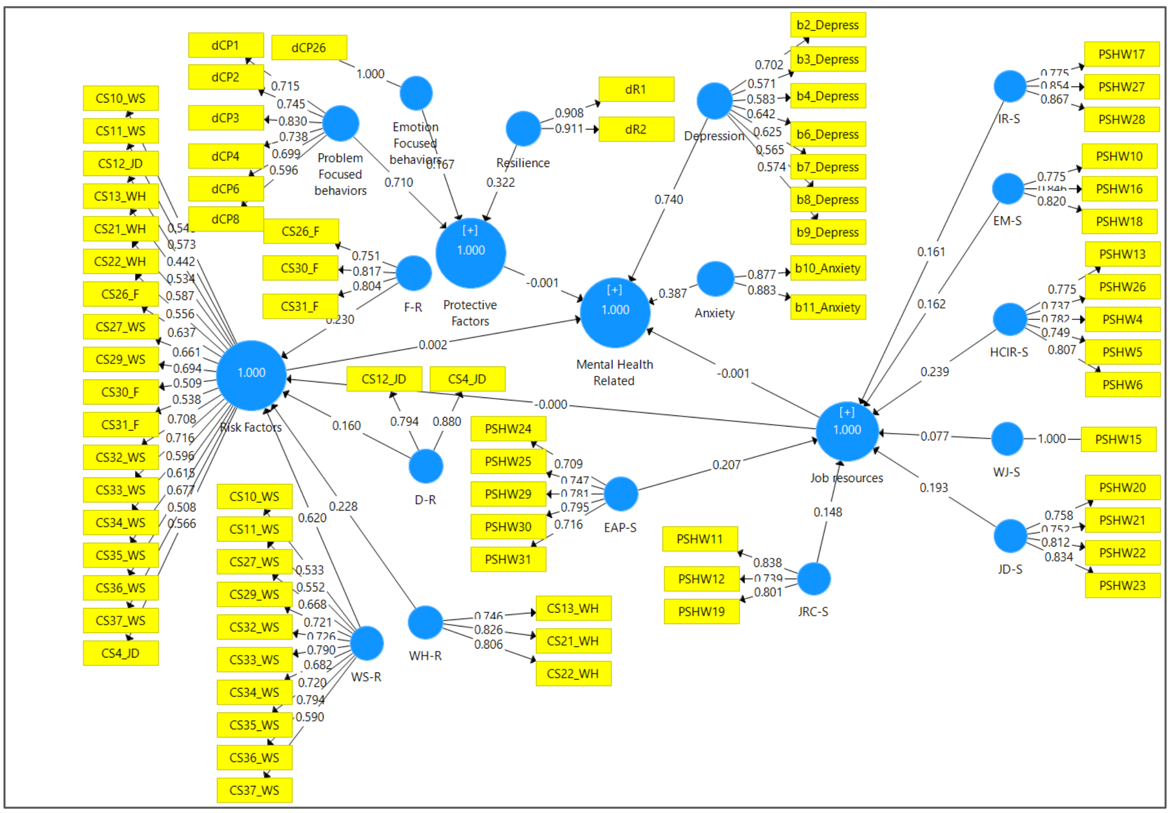

Figure 9. 1: Structural equation model showing the loadings

Table 9. 6: Direct Relationship for testing the hypothesis

Hypothesis			Standardized					Effect Size		95%CI	
Hypothesis	Relationship	Beta	Beta	Error	|t-value|^	P- values	Decision	f^2	q^2	LL	UL
$H4_2$	Job Resources -> MIH	0.062	0.060	0.065	0.947	0.172	Not supported	0.004	0.044	-0.048	0.163
$H4_1$	Job Resources -> Risk Factors	-0.121	-0.120	0.070	1.731*	0.042	Supported	0.015	-0.007	-0.002	-0.233
$H4_3$	Protective Factors -> MIH	-0.221	-0.218	0.069	3.200*	0.001	Supported	0.058	-0.004	-0.327	-0.101
$H1_1$	Risk Factors -> MIH	0.504	0.504	0.055	9.236*	0.000	Supported	0.359	0.350	0.411	0.591
Effect Size (R^2) and Predictive Relevance (Q^2)											
Path to MH	R^2		0.307								
	Q^2		0.028								
Path to Risk factors	R^2		0.015								
	Q^2		0.007								

Note: * significant at p value < 0.05; q^2 = Predictive Relevance.

9.3.3.2 Evaluation of the structural model

Bootstrapping result showed that all the strategies impacted the state of mental health (see Table 9.6). The paths testing hypothesis $H4_1$, $H4_3$, $H1_1$ was supported because the t-values were greater than the 1.65 (significance level = 0.1), 1.96 (significance level = 0.05), and 2.58 (significance level = 0.01) limits respectively. Overall, the result implied that job resources (i.e., intervention strategies) and protective factors mitigate mental ill-health while the risk factors increased mental ill-health. However, hypothesis $H4_2$ was not supported. As shown in Figure 9.2, the model depicting the impact of the risk factors, protective factors, and intervention strategies on the mental health of supervisors had an R^2 of 0.307, indicating a satisfactory predictive effect of the model (Hair et al., 2014). Figure 9.2 also shows that the impact of the intervention strategies on the risk factors was rather weak, with R^2 of 0.015.

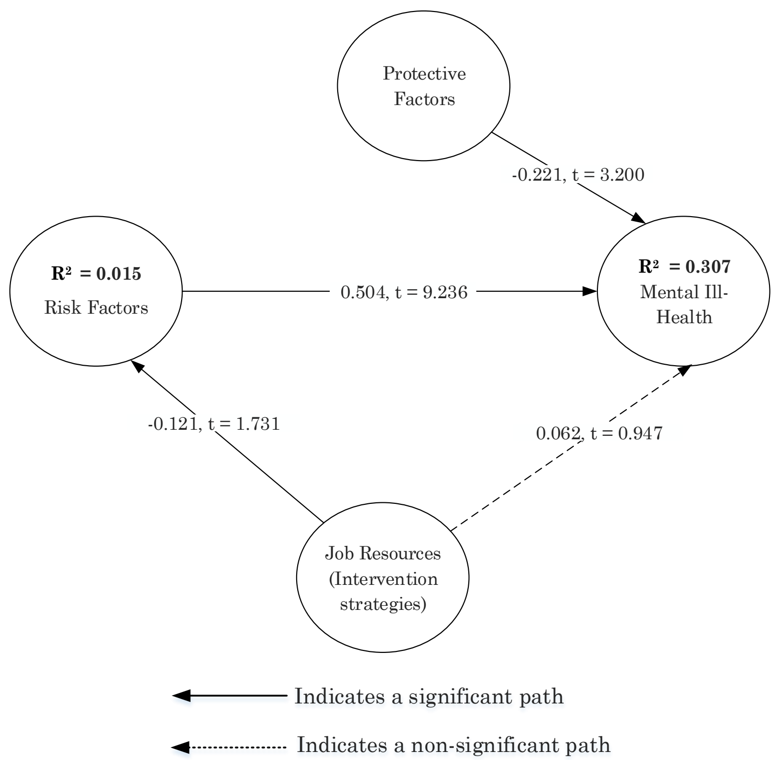

Figure 9. 2: Relationship between the Constructs and Mental Health

9.3.4 System dynamics

A causal loop diagram indicating the risk factors for mental ill-health and the interventions to mitigate or prevent the risk factors and ameliorate mental ill-health over time was developed (see Figure 9.3). The causal loop diagram was developed into a stock and flow diagram using the Vensim software (see Figure 9.4), upon which the simulation was based. The full model includes 17 auxiliary variables, seven levels, two lookups, 64 symbols, and 32 constants. The auxiliary variables represent the strength of impact of the risk factors. The model has to be parametrized before the simulation can be carried out. Thus, the time horizon for observing the system's behavior was set at 36 weeks to allow an adequate period. The odd ratio deduced from the logistic regression was entered as values for the risk factors. For the interventions, the baseline value was 1 representing the intervention's intensity. The panelists agreed upon the values during the expert discussion session. The model parameters and equations are shown in Appendix V. The simulation began by running a baseline simulation to test the effects of the risk factors. Thereafter simulation was run to test the effects of the intervention strategies and changes required to reduce the likelihood of developing mental ill-health symptoms.

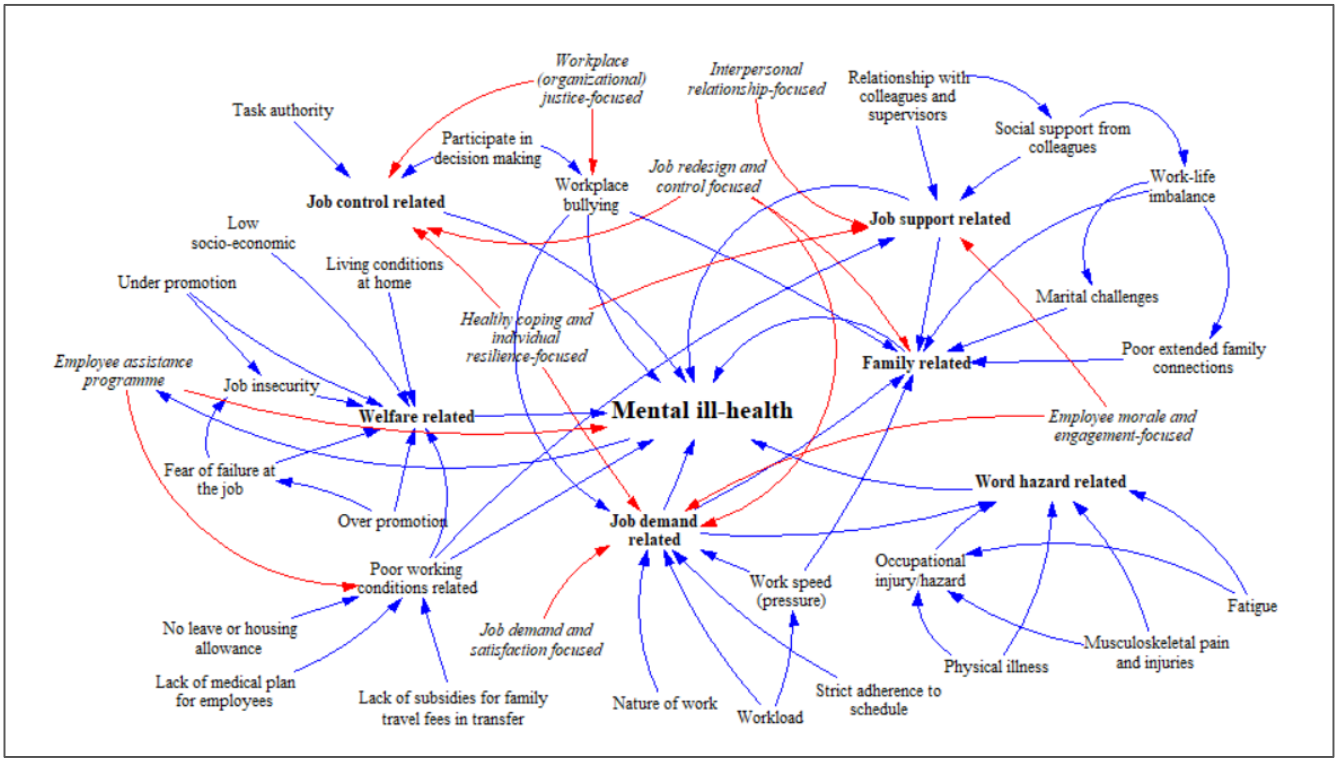

Figure 9. 3: Causal loop diagram for mental ill-health and intervention strategies

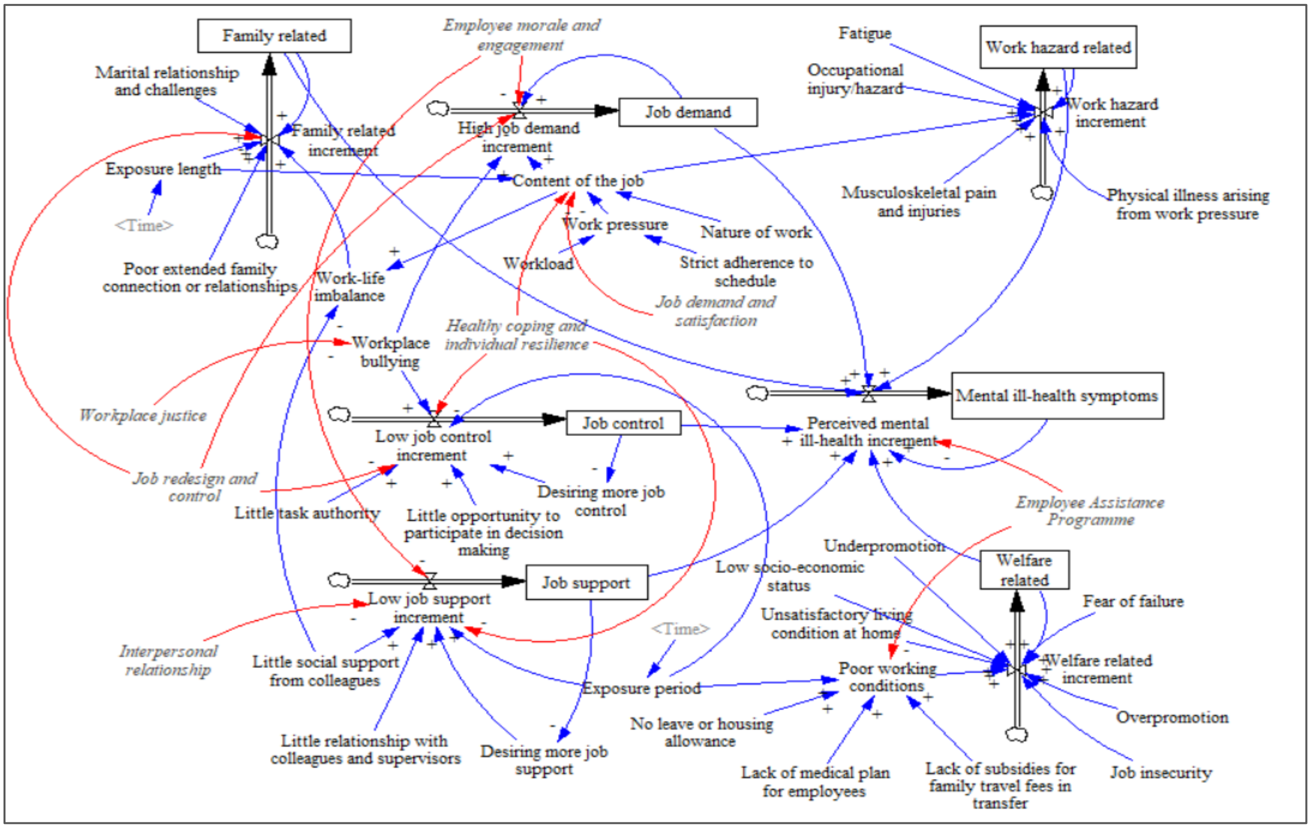

Figure 9. 4: Stock and flow diagram showing interventions interacting with risk factors

9.3.4.1 Simulation experiment and analysis

Simulation was used to assess the impact of single and multiple risk factors on baseline mental ill-health. Overall, it was deduced that an intervention variable value of 1 has little effect on long-term stress and mental ill-health symptoms, while a variable value of 3 has a three times effect.

9.3.4.1.1 Single-factor effects on mental health

Simulation was conducted to assess how changes to job control, job support, and job demand-related risk factors could impact baseline mental ill-health. As shown in Figure 9.5, reduced high job demand was associated with an exponential decrease in mental ill-health. It was observed that when job demand reduced by 25%, baseline mental ill-health decreased from 122.65 to 97.16 at week 6 and from 143.65 to 116.16 at week 36. Thus, amounting to a 20.78% and 17.74% reduction effect at week 6 and 36, respectively (see Appendix VI). On the contrary, increasing job control or job support by 25% (i.e., by reducing low job control or low job support by 25%) was associated with a slight decrease in mental ill-health (see Figure 9.6 and 9.7).

Specifically, on improving job control by 25% (i.e., by decreasing low job control), baseline mental ill-health decreased slightly from 122.65 to 118.99 at week 6 and from 143.65 to 139.99 at week 36 (see Appendix VII). Likewise, by improving job support by 25%, baseline mental ill-health slightly decreased from 122.65 to 119.16 at week 6 and from 143.65 to 140.16 at week 36 (see Appendix VIII). The job control had a 1.49% (week 6) and 1.27% (week 36) reduction effect, while job support had a reduction effect of 2.85% and 4.85% at week 6 and 36, respectively.

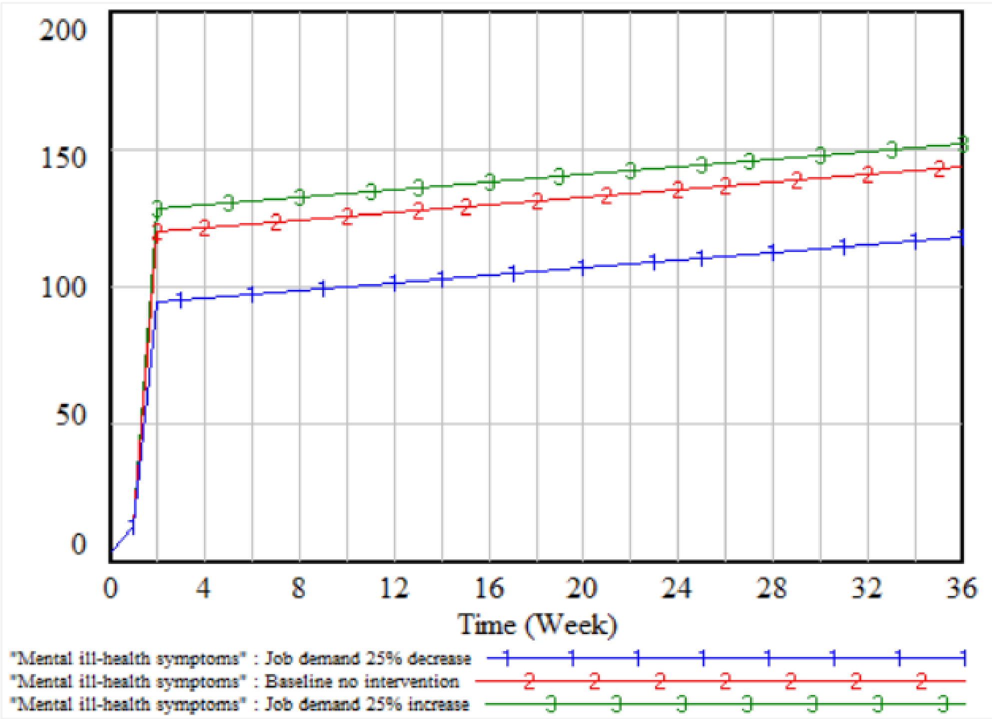

Figure 9. 5: Changes in mental ill-health based on changes in job demand

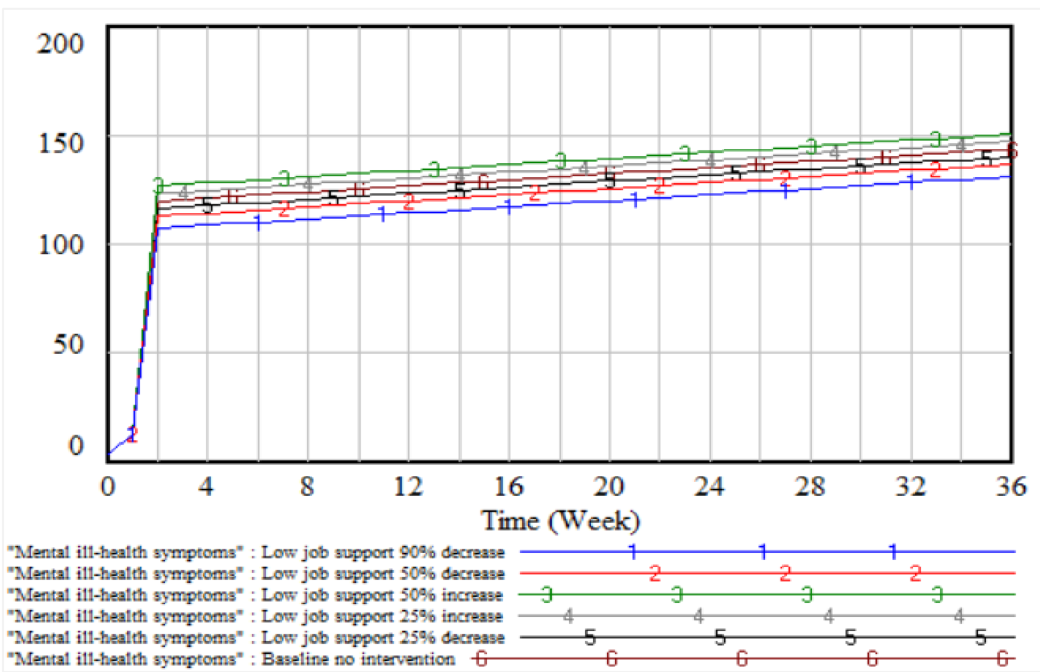

Figure 9. 6: Changes in mental ill-health based on changes in job support

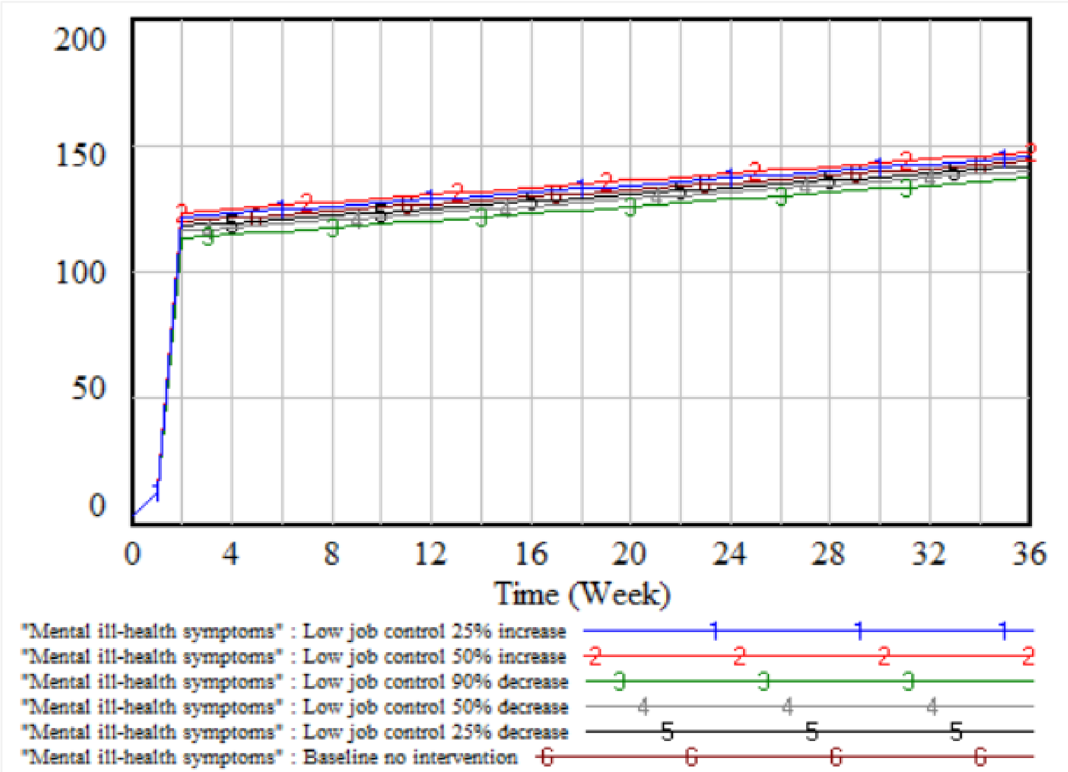

Figure 9. 7: Changes in mental ill-health based on changes in job control

9.3.4.1.2 Multiple factors effects on mental health

After evaluating the single-component effect, all the seven factors were simulated using a 50% reduction in job demand, family, workplace injustice, welfare, work hazard-related risk factors, and 90% reduction in low job control and support. In this study, decreasing job demand by 25% greatly improved mental ill-health conditions, while a 25% increase in job control or job support slightly improved the condition. However, considering the nature of the construction industry, it may not be feasible to reduce job demand and related constructs by 90%. Therefore, it was hypothesized that, to increase the impact of job control and support on stress sequence, low job control and low job support should be decreased by at least 90%, while other risk factors reduced by 50%. The simulation output indicated by Line 2 on Figure 9.8 showed that by decreasing all the risk factors, mental ill-health reduced from 122.65 to 64.73 at week 6 and from 143.65 to 85.73 at week 36, implying a 47.23% and 40.32% improvement in mental health.

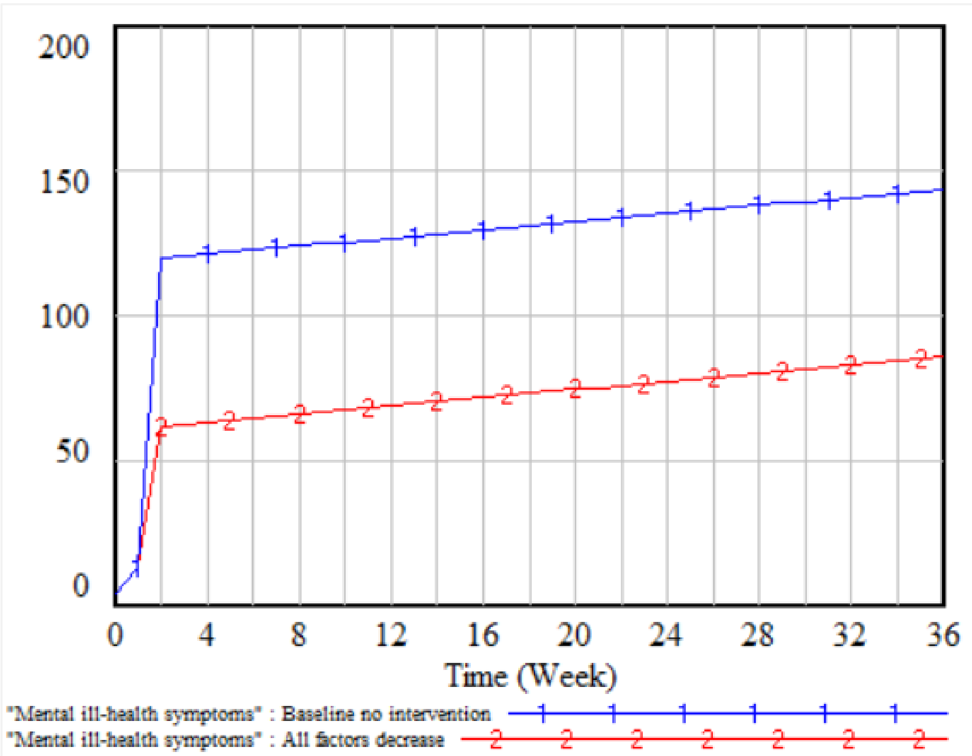

Figure 9. 8: Changes in mental ill-health based on changes in all risk factors

9.3.4.1.3 Single and multimodal interventions effects on mental health symptoms

The baseline simulation revealed that mental ill-health increased over a period of 36 weeks; 4 (0 weeks) to 122.65 (6 weeks) to 131.05 (18 weeks) to 143.65 at week 36, as indicated by Line 1 in Figure 9.9. The simulation also revealed that at an intensity value of 1, the combined intervention reduced mental ill-health slowly over a period of 36 weeks; from 122.65 (baseline 6 weeks) to 105.65 (6 weeks), 131.05 (baseline 18 weeks) to 114.05 (18 weeks), and 143.65

(baseline 36 weeks) to 126.65 (36 weeks). Specifically, at an intensity value of 1, the combined interventions indicated by Line 2 had a 14.02%, 12.97%, and 11.83% reduction effect at weeks 6, 18, and 36, respectively (see Appendix IX). On increasing the combined interventions by 200% (i.e., the intensity value of 2) indicated by Line 3, the reduction effect per week increased two times.

The effect of single interventions on mental ill-health varied from one intervention to another (see Figure 9.9 and Appendix X). It was observed that at an intensity value of 1, secondary intervention (SC3) indicated by Line 5 had a 4.08%, 3,81%, and 3.48% reduction effect in baseline mental ill-health at week 6, 18, and 36, respectively. At value 2, secondary intervention (SC3) had an 8.15% (week 6), 7.63% (week 18), and 6.96% (week 36) reduction effect on baseline mental ill-health (see Appendix VII). At an intensity value of 1, primary interventions (SC4, SC5, SC7) indicated by Line 6, reduced the baseline mental ill-health from 122.65 (6 weeks) to 114.65 (6 weeks), 131.05 (18 weeks) to 123.05 (18 weeks), 143.65 (36 weeks) to 136.65 (36 weeks), amounting to a 6.52%, 6.10%, and 5.57% reduction effect at 6, 18 and 36 weeks respectively on baseline simulation. Likewise, by increasing the primary intervention value to 2, there was a 13.05%, 12.21%, and 11.14% reduction effect at 6, 18, and 36 weeks respectively, from the baseline simulation.

At intensity value 1, combined primary and secondary interventions (SC1, SC2, SC3, SC4, SC5, SC7) indicated by Line 0 resulted in a 13.05%, 12.21%, and 11.14% reduction effect on baseline mental ill-health at week 6, 18, and 36, respectively (Figure 9.9). It was observed that the effect was the same as implementing a primary intervention (SC4, SC5, SC7) at an intensity value of 2 (Line 7). With multimodal interventions, the trend of increasing mental ill-health prevalence can be greatly mitigated. Therefore, to determine a stronger intervention effect necessary to reduce mental ill-health at week 36 by at least 40.32%, as shown by Line 2 in Figure 9.8, the formula was adopted:

$$\text{Intervention effect, y} = \frac{\text{percentage change when all factors were decreased without intervention}}{\text{lowest percentage change at baseline with intervention at value 1}} \quad \ldots\ldots\ldots\ldots (9.1)$$

Following eqn. (9.1), the intervention value was determined to be 4. As indicated by Line 4 in Figure 10, with a stronger multimodal intervention effect (e.g., increasing each intervention value to 4), at week 36, mental ill-health prevalence reduced by 47.2% to 75.65 from a baseline value of 143.65. Line 5 in Figure 8 shows that at an intervention value of 3.4, the effect of the combined intervention on alleviating long-term stress and mental ill-health is the same as reducing low job control and support by 90 percent, while other risk factors were reduced by 50 percent (Line 3).

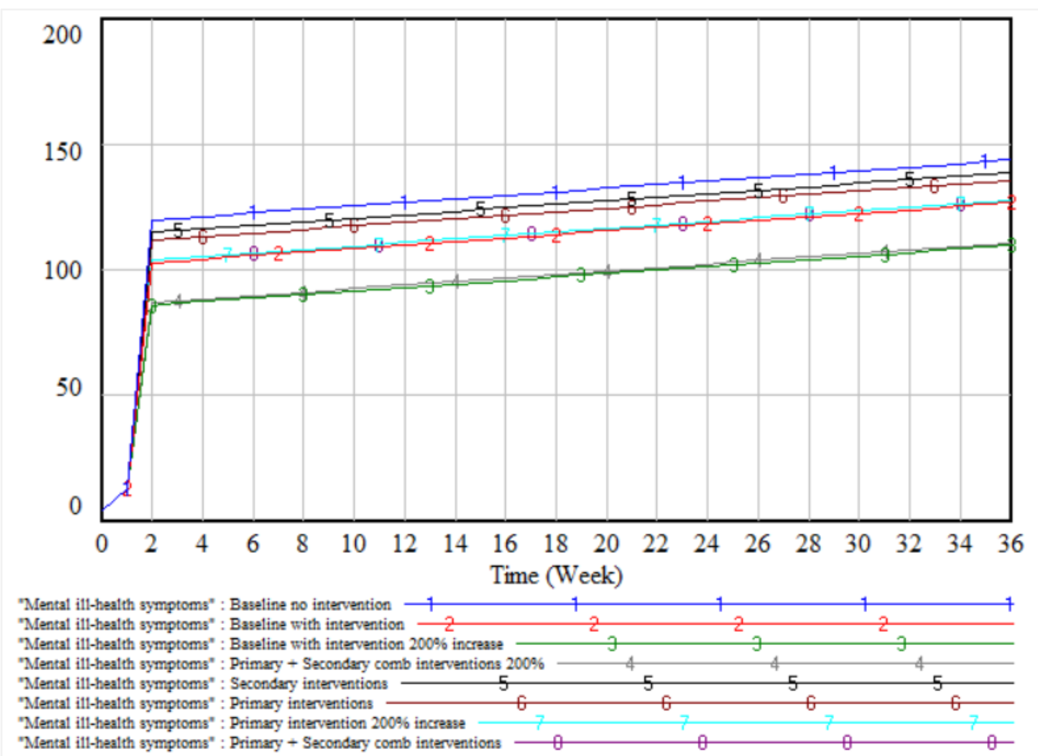

Figure 9. 9: Mental ill-health prevalence trend with intervention

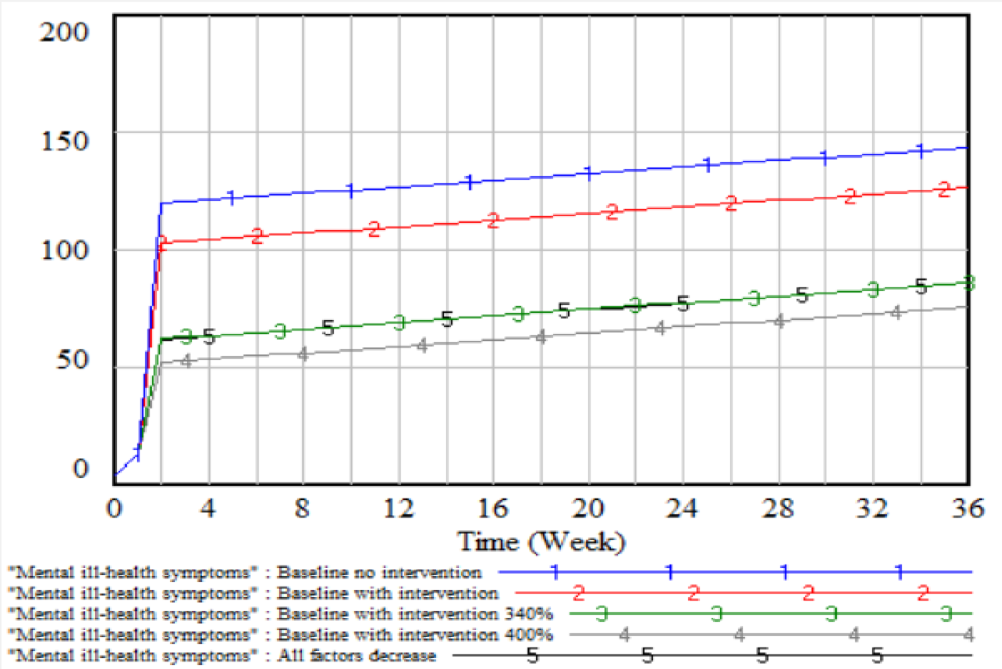

Figure 9. 10: The potential impact of mitigating risk factors over time

9.4 Discussion

9.4.1 Intervention strategies based on supervisor's perception

Like experts in the Nigerian construction industry (Nwaogu and Chan, 2021a), among the site supervisors, *"celebrating employee success"* and "*ensuring sustainable retirement plans for employees"* ranked as topmost essential intervention strategies. Contrary to the experts, the supervisors prioritize strategies to "*reduce the threatening of staff with disengagement*" as it ranked in the top three. Consistent with the experts' study, interpersonal relationship construct and employee morale and engagement-focused constructs ranked the highest among the supervisors. This reinforces the need for the strategies to be included as job resources for mental health promotion in the construction industry. The strategies are primary, secondary, and tertiary intervention-related, which points to the need for multi-modal interventions.

9.4.2 Quantifying the impact of risk, protective factors, and job resources on mental health

Although the stressors retained in the PLS/SEM model were only related to welfare and socioeconomic outlook, job demand, work hazard, and family, job resources that include primary, secondary and tertiary interventions were required in the model to mitigate the onset of the stressors. This reinforces that because risk factors do not act in isolation but are clustered together, an integrated approach is required to mitigate them and ameliorate their effects. The study showed that as the intensity of the stressors increased, mental ill-health increased. This further confirmed that stressors to which supervisors get exposed are risk factors for depression or anxiety. The integrated intervention strategies were deduced to mitigate the stressors, confirming hypothesis $H4_1$, while they did not directly mitigate mental ill-health, negating hypothesis $H4_2$.

However, since there exists a positive relationship between the stressors and poor mental health, if the strategies mitigate the stressors, the likelihood of the supervisors developing mental ill-health symptoms will be reduced. As the individual protective factors increased, mental ill-health reduced, confirming hypothesis $H4_3$. This emphasizes the impact of mitigating risk factors through an integrated approach to mental health promotion and enhancing individual protective factors.

9.4.3 Potential approaches and interventions for mental health improvement

The model consists of feedback loops, which illustrate the cyclical nature of stressors. The simulation reflects the persistence in the trend of mental ill-health over time. In this study, decreased job demand greatly improved mental health, while increased job control slightly improved mental health. This finding is consistent with Jetha et al. (2017), who found that a 25 percent decrease in job demand and 25 percent increase in job control, respectively, greatly and slightly decreased the prevalence of stress among nursing staff. Hence, this study suggests that changes to organizational culture in construction firms using the outlined measures can generate conditions that weaken risk factors and mental ill-health symptoms. The study indicates that to effectively reduce and prevent mental ill-health prevalence, the risk factors related to high job demand should be reduced by at least half. Simultaneously, strategies should be implemented to ensure that the supervisor's perception of job control and job support is continuously satisfactory. Therefore, measures to boost job control and support should be doubled to maintain the factors' protective ability.

A noteworthy finding was observed among single-component interventions. Primary interventions had the most significant mitigating impact on mental ill-health prevalence over the simulation period. Thus, affirming the importance of primary intervention as they are directed to the source of the stressor to eliminate or reduce it. Aligning with Brittin et al. (2015), the effect of single or multimodal interventions increased as the intervention's value increased. However, this study also affirmed that single component interventions do not significantly impact mental ill-health prevalence. Thereby, it highlights the need to adopt a holistic approach to reduce job demands, workplace injustice, work hazard, increase resources (e.g., job support, control, and welfare) so as to improve the experiences of stress and mental ill-health among construction supervisors.

This study shows that work-related stress and some nonwork stress, which may impact health and productivity, may be mitigated by designing primary, secondary, and tertiary interventions that address multiple risk factors. Furthermore, the study provides evidence that a stronger improvement in multimodal interventions would effectively ameliorate mental ill-health symptoms. Based on the SD model, findings point towards improving working conditions, job demand, job support, job control, work-life balance to change the perception of work and nonwork stress and their effects. Additionally, proper allocation of work duties and competence training can help eliminate concerns of under/over promotion and job insecurity.

9.5 Chapter Summary

The workplace is an appropriate avenue for mental health promotion as the working population spends about two-thirds of their time at work (Joyce et al., 2016). An effective promotion would begin by understanding what elements of the work pose stress to employees and nonwork stressors that may affect the workplace's motivation, followed by intervention strategies that can prevent or ease mental health problems. The study highlights the need for construction firms to holistically engage intervention strategies that target the organization level and individual level for a conclusive mental health and wellbeing outcome. The study suggests that to effectively mitigate and prevent mental ill-health prevalence, the risk factors related to job demand may need to be reduced by half. In contrast, job control and support factors need to be improved by almost two times in order to maintain their mental health protective ability.

By putting measures in place to address concerns relating to working conditions, job demand, job control, job support, work hazards, and family, organizations can have a primary, secondary preventive, and tertiary influence on construction supervisors' mental health and well-being. Additionally, given that the nature of the construction industry is largely the same irrespective of location, these findings provide some applicability to other climes. Therefore, this study recommends that the outlined intervention strategies should form the basis for policy/decision-making regarding appropriate measures to implement in the Nigerian construction industry.

While this chapter was used to achieve objective 4 of the research, the evaluation aspect of objective 3 was further achieved in the chapter by testing the hypothesis. This chapter sought to demonstrate the need to adopt an integrated approach for mental health promotion and develop an intervention system. PLS/SEM was used to quantify the impact of stressors, individual protective factors, and intervention strategies on mental health. Thereafter, system dynamics modeling was used to demonstrate the essence of engaging multimodal intervention strategies and their priority. The succeeding chapter (Chapter 10) details the aim of the research as it contains the mental ill-health prevention and mitigation framework.

CHAPTER 10: THE MENTAL ILL-HEALTH PREVENTION AND MITIGATION INTERVENTION FRAMEWORK

10.1 Preamble

In the preceding chapter, structural equation modeling and system dynamics modeling were used to harness objectives one and three. In the chapter, PLS/SEM was used to quantify the relationship between risk factors, protective factors, and the proposed intervention strategies. In addition, system dynamics modeling was used to emphasize the need to adopt integrated interventions for mental health by modeling the effect of multi-modal interventions and single-mode interventions over 36 weeks. In this chapter, the findings of all the four objectives used to achieve the research aim are harnessed into a workable framework based on the study's conceptual framework in Section 3.3. This chapter, therefore, presents the framework and its validation which involved 11 experts from both the industry and academia.

10.2 Validation of Research Findings

Research validation is an essential step in a research study because it is concerned with doing the research appropriately, thus, set out to determine the credibility of the research outputs (Lucko and Rojas Eddy, 2010). There are a number of validations, namely, construct validity, internal validity, external validity, and content validity. Internal validity deals with the causal relationships between the variables; external validity focuses on the generalization of the research findings; construct validity checks the appropriateness of the theoretical construct, and content validity focuses on whether the research findings are realistic.

10.3 The Mental Ill-Health Prevention and Mitigation Framework

The mental ill-health prevention and mitigation framework was arrived at by combining the results of all the research objectives. The mental ill-health prevention and mitigation framework can also be referred to as the "Integrated Mental Health Intervention Framework."

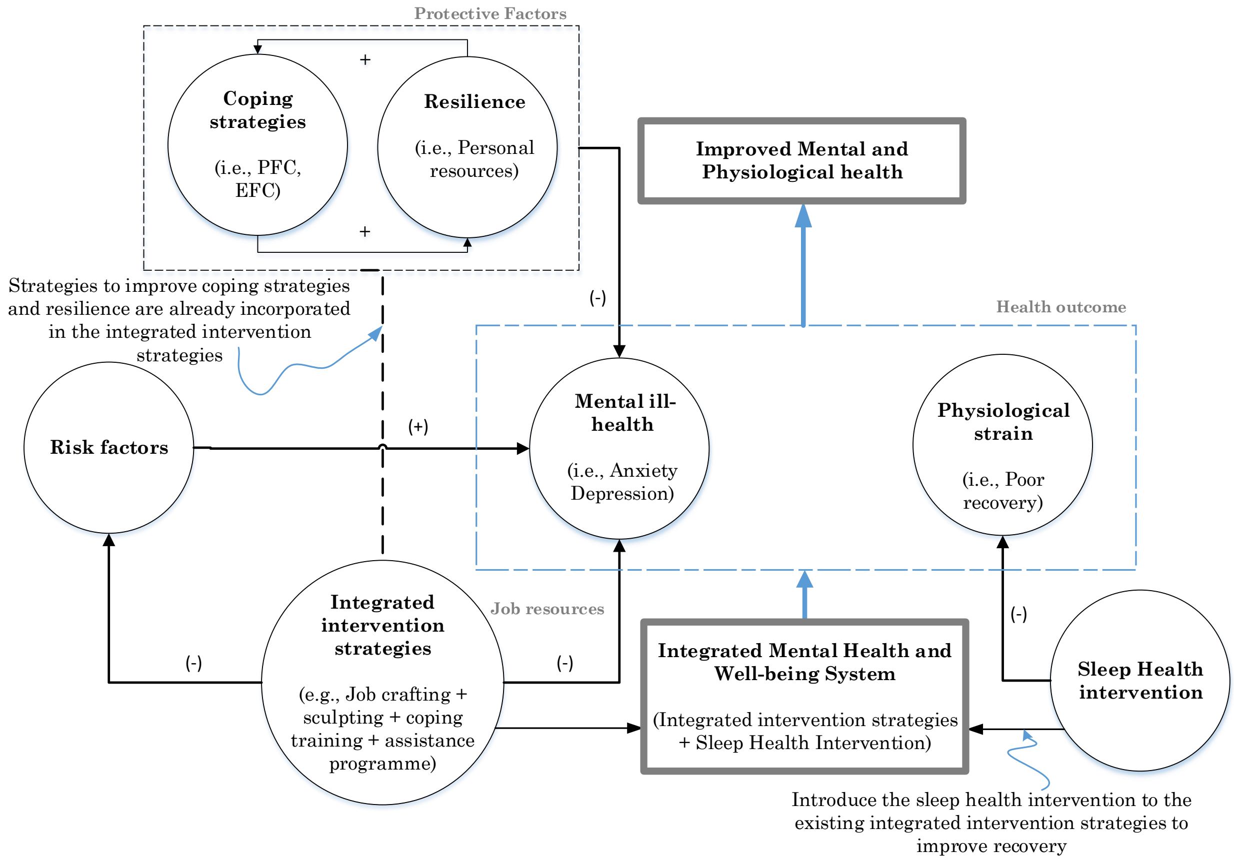

Figure 10. 1: Mental Ill-Health Prevention and Mitigation Intervention Framework

The framework emphasizes the need to implement integrated intervention strategies and sleep health interventions within the construction industry to improve construction personnel's mental health.

10.4 Validation Questionnaire

A validation questionnaire comprised of five statements was developed to determine the credibility and quality of the integrated mental ill-health intervention framework in preventing and mitigating mental ill-health among construction personnel. The questionnaire, a summary of the research findings, and manuscripts published from the study were sent via electronic mail to 16 experts. Out of which, eleven experts responded. Six of the respondents for the validation exercise partook in the process of developing causal diagrams for the system dynamics modeling, while the remaining experts included those who partook in the face validity and content validity for the research questionnaire. The validation questionnaire (see Appendix XI) was modified from Darko (2019). The respondents were required to indicate their level of agreement to the validation questions, using a four-point scale, where 1 indicates strongly disagree, and 4 indicates strongly agree. As earlier mentioned in Section 4.6.1, the four-point Likert scale was employed as an ipsative item to eliminate the bias of the neutral point of an odd-numbered scale (Brown, 2000). Therefore, the experts were forced to either disagree or agree with the statements. This was intended to improve the quality of the findings by removing bias which a neutral point would have caused.

10.4.1 Validation results

All the respondents had a minimum of 10 years of active working experience in academia or the construction industry. As shown in Table 10.1, the mean score of all the validity statements scored above 3.00; indicating that each statement was ranked within the agreement range. The result further shows that the experts considered the external validity, content validity, internal and external validity to be adequate. This implies that the results of each objective and the integrated framework are credible in achieving the aim of the research.

Table 10. 1: Validation results of the framework

Code	Validation Statements	Range of response		Total Score of Response	Mean Score	
		Minimum	Maximum		Mean	SD
V1	The risk factors and their constructs are reasonable	3	4	42	3.82	0.405
V2	The protective factors are appropriate	3	4	39	3.55	0.522
V3	The strategies within the strategy constructs are appropriate	3	4	39	3.55	0.522
V4	The integrated mental health promotion framework is understandable	3	4	41	3.73	0.467
V5	The integrated mental health promotion is suitable for mental health promotion in the Nigerian construction industry	3	4	39	3.55	0.522
V6	The integration of sleep management training into the final framework is understandable and reasonable	3	4	37	3.36	0.505
V7	The total sleep time to sleep score is useful for promoting adequate recovery following work stress	4	4	37	3.45	0.522

Note: SD – Standard Deviation

10.5 Chapter Summary

This chapter presented the integrated mental ill-health prevention and mitigation framework and the validation result for the framework and the entire research objectives. The research passed content, construct, internal and external validity. The succeeding chapter is the final chapter, and it details the research conclusions and recommendations.

CHAPTER 11: CONCLUSIONS AND RECOMMENDATIONS

11.1 Preamble

The preceding chapters detail the purpose and objectives of the research, the research methodology, results, and discussion of the findings. This chapter concludes this research study by detailing a summary of the research findings per objective, highlighting the significance of the research, its limitations, and recommending areas of further study.

11.2 Review of Research Objectives

The research was conducted to develop an intervention framework for the prevention and mitigation of mental ill-health in Nigeria's construction industry with a view to improving the health of construction personnel. In order to achieve the purpose of the research, four objectives were set out. A variety of research approaches were adopted to achieve the research objectives. Although the study was focused on site-based construction personnel engaged in building production and management (i.e., supervisors and tradesmen), the research approach varied across the objectives and included collecting data from three categories of respondents (namely supervisors, tradesmen, and experts).

The objectives are:

(i) Identify and assess the risk factors for mental ill-health and protective factors of mental health among construction personnel.

(ii) Assess the effect of work pressure in construction on the physiological health of construction personnel.

(iii) Identify and evaluate potential mental ill-health solutions for the construction industry.

(iv) Develop a mental ill-health prevention and mitigation intervention framework for the Nigerian construction industry.

11.2.1 Identify and assess the risk factors for mental ill-health and protective factors of mental health among construction personnel

The result for this objective is detailed in Chapters 6 and 7. This objective identified significant predictors of common mental ill-health amongst construction personnel engaged in building production management in Nigeria and was achieved by using questionnaire surveys and post-survey interviews to collect data. The study indicated a prevalence of depression than anxiety among construction personnel and that most of the risk factors for mental ill-health were work-related. Suicidal ideation had a prevalence rate among construction personnel higher than for the general population of Nigeria. Given that suicidal ideation is a significant predictor of actual suicide, this finding suggests that some personnel may be at risk of committing suicide. This signals that these common mental ill-health symptoms are an undetected challenge among construction personnel, and urgent interventions, such as mental health first aid and employee assistance program, are needed for preventing suicide in the Nigerian construction industry.

Job demand (e.g., Work overload, increased work speed) and welfare-related risk factors (e.g., job insecurity) are top causes of stress among supervisors and tradesmen, especially among the supervisors. Among tradesmen, stressors related to high demand (work hours worked per day), work hazards (physical illness caused by day's work), and low job control (little opportunity to participate in decision making), and career development were the top sources of stress. Among the construction personnel, common risk factors for mental ill-health were related to work and their personal life outside the workplace. The modifiable work-related risk factors were grouped as welfare and socio-economic outlook, job demands, job control, work support, work hazard, and family. Given that risk factors do not emerge in isolation but instead clustered together, interventions aimed at promoting construction personnel's mental health should be directed toward the clusters of risk factors.

This study revealed the role of resilience and problem-focused coping strategies as individual protective factors that reduces the risk of developing mental ill-health among construction personnel. Both tradesmen and supervisors used problem-focused coping strategies more frequently; however, adopting the strategies did not appear to control the adverse effect of stress among tradesmen effectively. The study confirmed that resilience is a vital coping resource. Thus, resilience training should form part of secondary interventions in the industry. This study highlights that resilience-building should be an integral part of any intervention on stress reduction and management in the construction industry.

Depression appeared to be more resistant to protective factors as no coping strategies protected personnel against depression. Based on the result, it can be deduced that if the protective factors form the basis for mental health intervention in the construction workplace, the negative impact of work and non-work stressors on mental health can be mitigated and prevented. There is a need to educate personnel on the positive and negative forms of religious coping and the best means to adopt such coping for improved health benefits, especially given that Nigerians have significant ties to religion.

11.2.2 Assess the effect of work pressure in construction on the physiological health of construction personnel

This objective was achieved through an experimental procedure, and the results are detailed in Chapter 8. This study indicated that while construction supervisors are subjected to high mental stress, tradesmen are subjected to more physical stress. The stress increases their vulnerability to endothelial dysfunction and other adverse health outcomes. The study deduced that there appeared to be an intense need for recovery after work. However, the impact of the work stress altered the recovery process, evident by low sleep quality. Aside from work pressure which may negatively impact sleep quality among the personnel, non-work factors such as personal commitment and behaviors contribute to poor sleep quality and sabotage proper recovery. Thus, there is a need for sleep management interventions in the construction industry.

To improve recovery process following a day's job, this study developed and validated two predictive models that can be useful in stress and sleep health interventions. The first model (HRV-sleep score model) will help in estimating sleep quality from collected HRV. For instance, if the predicted sleep score is within a fair sleep quality. The information could help construction personnel become proactive in maintaining a healthier sleep habit after work necessary to boost the work-stress recovery process. The second model (TST-sleep score model) will be useful in sleep management, especially among persons who cannot afford an activity tracker. The TST-sleep score model will help personnel in estimating how well they slept a previous night by merely keeping track of their sleep and wake time.

11.2.3 Identify and evaluate potential mental ill-health solutions for the construction industry

This objective was achieved through a quantitative survey, and the results are detailed in Chapters 8 and 9. Using a list of 31 strategies and 30 strategies among experts and construction supervisors, respectively. Data on the intervention strategies were collected from experts and supervisors to determine the perception of the two classes of construction professionals on job resources required and feasible for mitigating mental ill-health in the construction workplace. Both experts agreed on the importance of all the strategies in promoting mental health within the Nigerian construction industry. Experts and supervisors indicated that to improve mental health in the industry, job resources in construction organizations should include policies that: celebrate employees' success and ensure sustainable retirement plans. Also, the supervisors indicated an essential need “to reduce the threatening of staff with disengagement." On grouping the strategies into constructs, constructs that motivate employees and build interpersonal relationships ranked the highest among the experts and supervisors.

The constructs include primary, secondary, and tertiary intervention strategies, thus reinforcing the need for multi-modal interventions. Therefore, this study recommends that the outlined intervention strategies should form the basis for policy/decision-making regarding appropriate measures to implement in the Nigerian construction industry. Additionally, given that the nature of the construction industry is largely the same irrespective of location, these findings provide some applicability to other climes.

11.2.4 Develop a mental ill-health prevention and mitigation intervention framework for the Nigerian construction industry

This objective was achieved by using PLS/SEM to model the results from objectives 1 and 3 and using system dynamics modeling to simulate the impact of the job resources (i.e., the intervention strategies) on improving mental health (through the mental ill-health mitigation path) over a period of 36 weeks. Thereafter, the results of all the four objectives in the research were harnessed and used to arrive at the integrated mental ill-health prevention and mitigation intervention framework. The results of this objective are detailed in Chapters 9 and 10. Although the stressors retained in the PLS/SEM model were only related to welfare and socioeconomic outlook, job demand, work hazard, and family, job resources that include primary, secondary and tertiary interventions were required to mitigate the onset of risk factors. Thus, reinforcing the need to adopt an integrated approach to mitigate stressors and lessen their effects because risk factors do not act in isolation but are clustered together, so single modal interventions will be ineffective.

The system dynamics model consisted of feedback loops to illustrate the cyclical nature of stressors. The simulation reflected the persistence in the trend of mental ill-health over time by simulating the effect of single-mode interventions and multi-modal interventions. A noteworthy finding was observed among single-mode interventions. Primary interventions had the most significant mitigating impact on mental ill-health prevalence over the simulation period. Thus, affirming the importance of primary intervention as they are directed to the source of the stressors to eliminate or reduce them. The study also highlighted that decreased job demand greatly improved mental health, while increased job control slightly improved mental health. Thus, reflecting that to reduce and prevent mental ill-health prevalence effectively, risk factors related to high job demand should be reduced by at least half.

This further suggests that changes to organizational culture in construction firms using the outlined measures can generate conditions that weaken risk factors and mental ill-health symptoms. Simultaneously, strategies should be implemented to ensure that the supervisor's perception of job control and job support is continuously satisfactory. Therefore, measures to boost job control and support should be doubled to maintain the factors' protective ability.

11.3 Significance and Original Contributions of the Research

In order to achieve an integrated approach to mental health, risk factors to mental ill-health irrespective of their cause, needed to be identified, followed by determining individual characteristics that promote health and develop a system that addresses mental health problems and stressors that cause poor health among construction personnel irrespective of the cause. The significance and contribution of the study include:

(i) Maintaining the competitive advantage of construction organizations is difficult without a psychologically healthy workforce. Therefore, to strengthen policy-making, this study has investigated the impact of stress on site-based personnel's mental health in the Nigerian construction industry, determined modifiable risk factors for mental ill-health, the protective factors for mental health, and highlighted where to direct effective interventions. The study also recommended intervention strategies to mitigate risk factors. This study's findings will assist in developing interventions and policies within the construction industry in Nigeria and other countries. This study builds on existing studies by examining mental ill-health symptoms, suicidal ideation, and their risk factors among construction personnel. Information from a lower-middle-income country like Nigeria is expedient because it will influence decision-making beneficial to both individuals and organizations in similar contexts as well as high-income countries.

(ii) The study indicates that there is also a prevalence of depression than anxiety among construction personnel in Nigeria, similar to developed contexts like the United Kingdom. Also, it highlights the presence of suicidal ideation and the need to take appropriate measures to mitigate worsening mental ill-health conditions and suicidality in the global construction industry.

(iii) The study highlights that irrespective of context, work speed, workload, job insecurity, and poor working conditions are the most ranked stressors and prevalent risk factors for mental ill-health within the construction industry.

(iv) This research determined that construction personnel are at risk of adverse health outcomes with continued exposure to work-related stress and poor recovery. This study draws attention to the need to consider sleep health interventions for proper work-stress recovery and demonstrates the possibility of using physiological indicators to evaluate recovery abilities.

(v) Additionally, given a dearth in the literature on the subject of resilience as a coping resource in the construction industry, this study draws attention to increasing research into the role of resilience when evaluating effective stress-coping strategies among construction personnel. The study informs on appropriate target points for adequate application of primary, secondary, and tertiary interventions in dealing with the stress among construction personnel.

(vi) Considering that the construction industry is a major source of employment and gross domestic product to any nation, putting measures to improve construction personnel's mental health becomes a priority with promising benefits to both employees, employers, and society. The benefit to employees includes improved safety compliance, increased performance, improved psychological and physiological health. Subsequently, benefits to employers are increased productivity, reduced lost-work hours, and reduced compensation.

(vii) The study employed the JD-R theory by conceptualizing that in adapting the theory in the construction industry: (i) job resources should be replaced with the intervention strategies; (ii) job sculpting should be introduced to job crafting, and both should form part of the intervention strategies; (iii) the intervention strategies will improve coping strategies and resilience level as well as mitigate risk factors and poor mental health symptoms; (iv) sleep intervention will improve physiological health.

11.4 Limitations

There are some limitations to this study. First, data for this research was collected from two major cities (Abuja and Lagos) in Nigeria with a beehive of construction activities. Thus, the findings may not generalize to the entire construction industry in the country. However, this study provides a foundation for works in this area within the Nigerian construction industry by spurring research focus and policies on this topic. While the research may not offer a generalization, they certainly help highlight action points for designing effective interventions to improve mental health, well-being, and safety among construction personnel. Second, some of the data relied on self-reports, which may cause response bias. Although this study employed a self-reported questionnaire, which may be subjected to individual bias, the consistency of the result with previous studies indicates that using validated psychometric instruments helped reduce bias. Lastly, the HRV data was collected for only two hours and thirty minutes because the study was cross-sectional in nature.

11.5 Recommendations for Future Study

By putting measures in place to address concerns relating to working conditions, job demand, job control, job support, work hazards, and family, organizations can have a primary, secondary preventive, and tertiary influence on construction personnel' mental health and well-being.

(i) Future research should expand the scope of this study to include the perceived effect of stressors on safety compliance and accidents in the construction industry. Such research should use structural equation modeling to quantify the effect of risk factors, protective factors, and mental ill-health symptoms on safety.

(ii) Further studies may consider the impact of psychological contracts on mental health in lower-middle-income countries.

(iii) Although this research did not find gender to be a significant predictor of mental health, further studies should examine the impact of personal characteristics such as gender, age, personality traits on the state of mental health.

(iv) Further studies should be conducted on construction personnel to gain insight into the unique risk factors for mental ill-health specific to the line and top management construction personnel as well as each trade within the construction industry. This will enhance the building of appropriate interventions for each unique occupation.

(v) Further studies involving HRV and sleep data are recommended to be longitudinal so that data can be collected for the same period or longer durations over two or more days from each participant.

(vi) Further studies should use the finding of this research to design a protocol for randomized control trials (RCT) for mental health intervention in the construction industry. The RCT should collect mental health information at baseline, short term, and long term after implementing the intervention strategies.

11.6 Chapter Summary

This chapter presented a summary of the research findings and recommended some areas for further research. Additionally, the limitations of the study, the significance, and the contributions of the study were outlined in this chapter.

APPENDIX

Appendix I: Questionnaire A "Construction Supervisors Survey"

Dear Sir/ Madam,

<u>Invitation to participate in a Doctor of Philosophy (Ph.D.) research on psychological health in the Construction Industry</u>

As a construction industry personnel, you are invited to participate in this survey aimed at **"Improving the Psychological Health of Construction Personnel in Nigeria."** The research is supported by the Department of Building and Real Estate, The Hong Kong Polytechnic University, through a supervisor's grant. The study is under the supervision of Chair Professor Albert P.C. Chan.

The questionnaire is estimated to take approximately 40minutes to complete, I plead for your patience. **Kindly fill the questions as they relate to you personally**. Please, note that all information provided is strictly for academic purposes and will be treated confidentially in line with the University Human Research Ethical Procedures.

For any enquiries, you can contact the researcher on Tel.: +852-5224 (Whatsapp) or email: janet.nwaogu@ .

I am thanking you in anticipation of your support.

Yours sincerely,

…………………………………

Janet M. Nwaogu, Ph.D. Candidate
Department of Building and Real Estate
The Hong Kong Polytechnic University, Hong Kong.

Section A:

1) Gender: Male ☐ Female ☐

2) What is the number of employees in the firm, you are currently working?
a) Micro firm: less than 10 employees ☐ (b) Small firm: 10-49 employees ☐
(c) Medium 50-199 ☐ (d) Large Firms 200 and above ☐

3) What type of projects does your firm execute? (tick all that apply)
a) Residential Building Projects ☐ (b) Civil Engineering/Infrastructural projects ☐
(c) Commercial/industrial buildings ☐ (d) Other(s) ______________________________

4) Years of practical experience in the construction industry?
a) less than 1-5 yrs ☐ b) 6-10yrs ☐ c. 11-15yrs ☐ d. 16-20yrs e. 21-25yrs ☐
f) Over 25yrs ☐

5) What is your supervisory job title called in the firm:
a) Project Manager ☐ (b) Site Engineer ☐ (c) Assistant Site Engineer/Site supervisors ☐

d) Site Supervisor ☐ (e) others ____________________

6) Kindly tick your highest qualification obtained.

a) Ordinary National Diploma ☐
b) Higher National Diploma ☐
c) Post Graduate Diploma ☐
c) Bachelors' degree ☐
d) MSc. ☐
e) MPhil. ☐
f) Ph.D. ☐
g) Others (please state) ………………………………….

7) How do you perceive the organizational structure of the firm?
a) Formal ☐ (b) Informal ☐

8) Based on your knowledge, please kindly mark your understanding of the organizational structure.
(a) Flat structure ☐

(b) Hierarchical/Pyramid Structure ☐

(c) Matrix Structure ☐

9) Is the organization structure in your firm clearly communicated to employees?
a) Yes ☐ (b) No ☐

Section B: Over the last two (2) weeks, how many days have you experienced the following issues?
(Kindly mark "✔" in the box that best fits your response)

PHQ-9 QUESTIONNAIRE				
Symptoms	**Never**	**Several days**	**More than half the days**	**Nearly every day**
Little interest or pleasure in doing things	☐	☐	☐	☐
Feeling down, depressed, or hopeless	☐	☐	☐	☐
Trouble falling or staying asleep, or sleeping too much	☐	☐	☐	☐
Feeling tired or having little energy	☐	☐	☐	☐
Poor appetite or overeating	☐	☐	☐	☐
Feeling bad about yourself — or that you are a failure or have let yourself or your family down	☐	☐	☐	☐
Trouble concentrating on things, such as doing your job duties	☐	☐	☐	☐
Moving or speaking so slowly that other people could have noticed? Or the opposite — being so fidgety or restless that you have been moving around a lot more than usual	☐	☐	☐	☐

GAD-2 QUESTIONNAIRE				
Symptoms	**Never**	**Several days**	**More than half the days**	**Nearly every day**
Thoughts that you would be better off dead or of hurting yourself in some way	☐	☐	☐	☐
Feeling nervous, anxious, or on edge	☐	☐	☐	☐
Not being able to stop or control worrying	☐	☐	☐	☐

Section C: Over the past 12 months, to what extent have the following issues created stress for you?
(Mark "✔" in the box that best fits your response)

Sources of stress	**Never**	**Very little**	**Moderately**	**Very great**
Physical illness arising from work pressure	☐	☐	☐	☐
Nature of work causing increased mental demand	☐	☐	☐	☐
Hours worked per day	☐	☐	☐	☐
Workload	☐	☐	☐	☐
Increased work speed	☐	☐	☐	☐
Little opportunity to participate in decision making	☐	☐	☐	☐
Little social support from colleagues and supervisors	☐	☐	☐	☐
Little relationship with colleagues and supervisors	☐	☐	☐	☐
Occupational injury/hazard	☐	☐	☐	☐
Poor working conditions (e.g., no leave or housing allowance)	☐	☐	☐	☐
Job insecurity	☐	☐	☐	☐
Strict adherence to time or schedule	☐	☐	☐	☐
Fatigue resulting from work causing poor sleep and recovery	☐	☐	☐	☐
Criticisms from superiors	☐	☐	☐	☐

Sources of stress	**Never**	**Very little**	**Moderately**	**Very great**
Lack of feedback mechanism in place	☐	☐	☐	☐
Low socio-economic status	☐	☐	☐	☐
Over promotion	☐	☐	☐	☐
Little task authority	☐	☐	☐	☐
Fear of failure at the job	☐	☐	☐	☐
Interpersonal conflict at work	☐	☐	☐	☐
Musculoskeletal pain and injuries	☐	☐	☐	☐
Poor physical working condition	☐	☐	☐	☐
Lack of respect from subordinates	☐	☐	☐	☐
Workplace harassment	☐	☐	☐	☐
Workplace bullying	☐	☐	☐	☐
Work-home/life imbalance	☐	☐	☐	☐
Low income causing financial insecurity	☐	☐	☐	☐
Salaries not paid on time	☐	☐	☐	☐
Unsatisfactory living condition at home	☐	☐	☐	☐
Past traumatic experience	☐	☐	☐	☐
Marital relationship and challenges	☐	☐	☐	☐
Poor family connection or relationships	☐	☐	☐	☐
Under promotion	☐	☐	☐	☐
Lack of a medical plan for employees	☐	☐	☐	☐
Lack of subsidies for family travel fees in the case of a transfer	☐	☐	☐	☐
Lack of opportunity for career development	☐	☐	☐	☐
Lack of opportunity for promotion	☐	☐	☐	☐
Lack of team or departmental or company social get-togethers	☐	☐	☐	☐

Section D: The table below provides a list of measures that can protect a person from experiencing too much stress. (Kindly mark "✔" in the box that best fits your response)

D1: Please tell us how you typically respond to stressful situations.

BRS QUESTIONNAIRE					
Respond to each statement below by ticking one answer per row	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I tend to bounce back quickly after a hard time of stress	☐	☐	☐	☐	☐
I have a hard time making it through stressful events	☐	☐	☐	☐	☐
It does not take me long to recover from a stressful event	☐	☐	☐	☐	☐
It is hard for me to snap back when something bad happens	☐	☐	☐	☐	☐
I come through difficult times with little trouble	☐	☐	☐	☐	☐
It tend to take a long time to get over setbacks in my life	☐	☐	☐	☐	☐

Section D Continued: The table below provides a list of measures that can protect a person from experiencing too much stress. (Kindly mark "✔" in the box that best fits your response)

D2: Please tell us how you typically respond to stressful situation

Ways of Coping Questions (WCQ)				
Think of a specific stressful situation that occurred over the last 12 months and how you responded to it				
Strategies employed	**Not at all**	**Very little**	**Frequently**	**Always**
I knew what had to be done, so I doubled my efforts to make the thing work	☐	☐	☐	☐
I came up with a couple of different solutions to the problem	☐	☐	☐	☐
I made a plan of action and followed it	☐	☐	☐	☐
I came out of the experience better than when I went in	☐	☐	☐	☐
I changed or grew as a person in a good way	☐	☐	☐	☐
I rediscovered what is important in life	☐	☐	☐	☐
I found a new faith	☐	☐	☐	☐
I prayed to withstand or succeed	☐	☐	☐	☐
I talked to someone who could do something concrete about the problem	☐	☐	☐	☐
I talked to someone to find out more about the situation	☐	☐	☐	☐
I talked to someone about how I was feeling	☐	☐	☐	☐
I expressed anger to the person who caused the problem	☐	☐	☐	☐
I tried to get the person responsible to change his or her mind	☐	☐	☐	☐
I realized I had brought the problem on myself	☐	☐	☐	☐
I criticized or lectured myself	☐	☐	☐	☐
I made a promise to myself that things would be different next time	☐	☐	☐	☐
I wished that the situation would go away or somehow be over	☐	☐	☐	☐
I had fantasies about how things might turn out	☐	☐	☐	☐
I kept others from knowing how bad things were	☐	☐	☐	☐
I tried to lose myself for a while by smoking	☐	☐	☐	☐
I used alcohol to make myself feel better	☐	☐	☐	☐
I tried to make myself feel better by eating	☐	☐	☐	☐
I let my feelings out like crying or venting my emotions	☐	☐	☐	☐
I didn't let it get to me and refused to think about it too much	☐	☐	☐	☐
I went on as if nothing had happened	☐	☐	☐	☐
I made light of the situation and refused to get too serious about it	☐	☐	☐	☐

Section E:

14) Are there any policies or systems in your workplace for ensuring good psychological health and well-being of personnel?

a) Yes ☐ b) No ☐ c) I don't know of any ☐

15) Are the policies/systems effective?
a) Yes ☐ b) No ☐ c) I don't know ☐

16) If there are any psychological health and well-being policy or system in your company? Kindly state below

____

17) What would you like your firm to put in place to **create a more psychologically healthy workplace**?
(Mark "✔" in the box to best describe your level of agreement to the importance of each strategy)

Strategies for mental health promotion	**Strongly disagree**	**Disagree**	**Agree**	**Strongly Agree**
Empower staff to be individually more resilient through resilience training programs	☐	☐	☐	☐
Introduce wellness programs to workplaces/site offices	☐	☐	☐	☐
Promote talks about anti-stigma (i.e., anti-stigma campaign)	☐	☐	☐	☐
Promote mental health awareness	☐	☐	☐	☐
Put measures in place for exercises such as exercise weekends or challenge, or going for walks	☐	☐	☐	☐
Provide practical stress management training	☐	☐	☐	☐
Create policies to eliminate bullying	☐	☐	☐	☐
Create policies to eliminate harassment	☐	☐	☐	☐
Promote equality policies irrespective of gender, and age	☐	☐	☐	☐
Promote employee's deeply embedded life interest (i.e., as a supervisor, if your life's interest is mentoring and career building, your job roles should include that interest of yours, e.g., anchor retraining or upskilling for subordinates).	☐	☐	☐	☐
As an employee, you should be allowed some flexibility to design your job roles and tasks while, human resources, approves it inline with the job position and goals of the organisation	☐	☐	☐	☐
Your workplace should allow to a flexible work schedule, with regards to your work time and duration with no intention to reduce productivity or performance	☐	☐	☐	☐
Put better education policies in place (e.g., providing subsidies for / encouraging employee career development	☐	☐	☐	☐
Reduce threatening of staff with disengagement when they make mistakes	☐	☐	☐	☐
Give constructive feedbacks instead of reprimanding	☐	☐	☐	☐
Ensure swift conflict resolution	☐	☐	☐	☐
Celebrate employee's success	☐	☐	☐	☐
Offer employee's opportunities to balance work and life	☐	☐	☐	☐
Allow the taking of regular breaks to enable rest	☐	☐	☐	☐
Better planning of work tasks and shifts	☐	☐	☐	☐
Hire more personnel to reduce the workload	☐	☐	☐	☐
Conduct employee satisfaction surveys	☐	☐	☐	☐
Conduct regular team meetings with supervisors to focus on addressing work stress	☐	☐	☐	☐
Promote communication about work stress without penalty	☐	☐	☐	☐
Provide employees with competence training	☐	☐	☐	☐

Measures	**Strongly disagree**	**Disagree**	**Agree**	**Strongly Agree**
Supporting improved relationships at work	☐	☐	☐	☐
Put in place measures that increase cooperation between supervisors and subordinates	☐	☐	☐	☐
Offer assistance to non-work stressors such as marital, family or relationship challenges or lifestyle challenges	☐	☐	☐	☐
Provide aid for stressors such as financial challenges	☐	☐	☐	☐
Offer a sustainable retirement plan for employees	☐	☐	☐	☐

Appendix II: Questionnaire B "Survey to Tradesmen"

Dear Sir/ Madam,

<u>Invitation to participate in a Doctor of Philosophy (Ph.D.) research on psychological health in the Construction Industry</u>

As a tradesman in the Nigerian construction industry, you are invited to participate in this survey aimed at **"Improving the Psychological Health of Construction Personnel in Nigeria."** The research is supported by the Department of Building and Real Estate, The Hong Kong Polytechnic University, through a supervisor's grant. The study is under the supervision of Chair Professor Albert P.C. Chan.

The questionnaire is estimated to take approximately 40minutes to complete, I plead for your patience. **Kindly fill the questions as they relate to you personally**. Please, note that all information provided is strictly for academic purposes and will be treated confidentially in line with the University Human Research Ethical Procedures.

For any enquiries, you can contact the researcher on Tel.: +852-5224 (Whatsapp) or email: janet.nwaogu@ .

I am thanking you in anticipation of your support.

Yours sincerely,

…………………………………

Janet M. Nwaogu, Ph.D. Candidate
Department of Building and Real Estate
The Hong Kong Polytechnic University, Hong Kong.

Section A:

1) Gender: Male ☐ Female ☐

2) What is the number of employees in the firm, you are currently working?
a) Micro firm: less than 10 employees ☐ (b) Small firm: 10-49 employees ☐
(c) Medium 50-199 ☐ (d) Large Firms 200 and above ☐

3) What type of projects does your firm execute? (tick all that apply)
a) Residential Building Projects ☐ (b) Civil Engineering/Infrastructural projects ☐
(c) Commercial/industrial buildings ☐ (d) Other(s) ______________________________

4) Years of practical experience in the construction industry?
a) less than 1-5 yrs ☐ b) 6-10yrs ☐ c. 11-15yrs ☐ d. 16-20yrs e. 21-25yrs ☐
f) Over 25yrs ☐

5) What is your trade are you engaged in the firm? Kindly mention ______________

6) Kindly tick your highest qualification obtained.

a) Secondary School Leaving Certificate ☐
b) Trade Test ☐
c) National Vocational Qualification ☐
d) Ordinary National Diploma ☐
e) Higher National Diploma ☐
f) City and Guilds ☐
g) Others (please state) ………………………………….

7) How do you perceive the organizational structure of the firm?
a) Formal ☐ (b) Informal ☐

8) Based on your knowledge, please kindly mark your understanding of the organizational structure.
(a) Flat structure ☐

(b) Hierarchical/Pyramid Structure ☐

(c) Matrix Structure ☐

9) Is the organization structure in your firm clearly communicated to employees?
a) Yes ☐ (b) No ☐

Section B: Over the last two (2) weeks, how many days have you experienced the following issues?
(Kindly mark "✔" in the box that best fits your response)

PHQ-9 QUESTIONNAIRE				
Symptoms	**Never**	**Several days**	**More than half the days**	**Nearly every day**
Little interest or pleasure in doing things	☐	☐	☐	☐
Feeling down, depressed, or hopeless	☐	☐	☐	☐
Trouble falling or staying asleep, or sleeping too much	☐	☐	☐	☐
Feeling tired or having little energy	☐	☐	☐	☐
Poor appetite or overeating	☐	☐	☐	☐
Feeling bad about yourself — or that you are a failure or have let yourself or your family down	☐	☐	☐	☐
Trouble concentrating on things, such as doing your job duties	☐	☐	☐	☐
Moving or speaking so slowly that other people could have noticed? Or the opposite — being so fidgety or restless that you have been moving around a lot more than usual	☐	☐	☐	☐

GAD-2 QUESTIONNAIRE				
Symptoms	**Never**	**Several days**	**More than half the days**	**Nearly every day**
Thoughts that you would be better off dead or of hurting yourself in some way	☐	☐	☐	☐
Feeling nervous, anxious, or on edge	☐	☐	☐	☐
Not being able to stop or control worrying	☐	☐	☐	☐

Section C: Over the past 12 months, to what extent have the following issues created stress for you?
(Mark "✔" in the box that best fits your response)

Sources of stress	**Never**	**Very little**	**Moderately**	**Very great**
Physical illness caused by day work	☐	☐	☐	☐
Hours worked per day	☐	☐	☐	☐
Workload	☐	☐	☐	☐
Increased work speed	☐	☐	☐	☐
Little opportunity to participate in decision making	☐	☐	☐	☐
Little support from colleagues and supervisors	☐	☐	☐	☐
Little relationship with colleagues and supervisors	☐	☐	☐	☐
Occupational injury or hazard	☐	☐	☐	☐
Job insecurity	☐	☐	☐	☐
Fatigue resulting from work causing poor sleep and recovery	☐	☐	☐	☐
Criticisms from superiors	☐	☐	☐	☐
Lack of feedback mechanism in place	☐	☐	☐	☐
Low socioeconomic status	☐	☐	☐	☐
Over promotion	☐	☐	☐	☐

Sources of stress	**Never**	**Very little**	**Moderately**	**Very great**
Little task authority	☐	☐	☐	☐
Fear of failure at the job	☐	☐	☐	☐
Interpersonal conflict at work	☐	☐	☐	☐
Musculoskeletal pain and injuries	☐	☐	☐	☐
Poor physical working condition	☐	☐	☐	☐
Lack of respect from subordinates	☐	☐	☐	☐
Workplace harassment	☐	☐	☐	☐
Workplace bullying	☐	☐	☐	☐
Work-home/life imbalance	☐	☐	☐	☐
Low income causing financial insecurity	☐	☐	☐	☐
Salaries not paid on time	☐	☐	☐	☐
Unsatisfactory living condition at home	☐	☐	☐	☐
Past traumatic experience	☐	☐	☐	☐
Marital relationship and challenges	☐	☐	☐	☐
Poor family connection or relationships	☐	☐	☐	☐
Lack of medical subsidies plan	☐	☐	☐	☐
Lack of opportunity for career development	☐	☐	☐	☐
Lack of opportunity for promotion	☐	☐	☐	☐
Lack of team or departmental or company social get-togethers	☐	☐	☐	☐

Section D: The table below provides a list of measures that can protect a person from experiencing too much stress. (Kindly mark "✔" in the box that best fits your response)

D1: Please tell us how you typically respond to stressful situations.

BRS QUESTIONNAIRE					
Respond to each statement below by ticking one answer per row	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I tend to bounce back quickly after a hard time of stress	☐	☐	☐	☐	☐
I have a hard time making it through stressful events	☐	☐	☐	☐	☐
It does not take me long to recover from a stressful event	☐	☐	☐	☐	☐
It is hard for me to snap back when something bad happens	☐	☐	☐	☐	☐
I come through difficult times with little trouble	☐	☐	☐	☐	☐
It tend to take a long time to get over setbacks in my life	☐	☐	☐	☐	☐

Section D Continued: The table below provides a list of measures that can protect a person from experiencing too much stress. (Kindly mark "✔" in the box that best fits your response)

D2: Please tell us how you typically respond to stressful situation

Ways of Coping Questions (WCQ)				
Think of a specific stressful situation that occurred over the last 12 months and how you responded to it				
Strategies employed	**Not at all**	**Very little**	**Frequently**	**Always**
Knew what had to be done, so I doubled my efforts to make the thing work	☐	☐	☐	☐
Came out with a couple of different solutions to the problem	☐	☐	☐	☐
Made a plan of action and followed it	☐	☐	☐	☐
Came out of the experience better than when I went in	☐	☐	☐	☐
Changed or grew as a person in a good way	☐	☐	☐	☐
Rediscovered what is important in life	☐	☐	☐	☐
Found a new faith	☐	☐	☐	☐
Prayed to withstand or succeed	☐	☐	☐	☐
Talked to someone who could do something concrete about the problem	☐	☐	☐	☐
Talked to someone to find out more about the situation	☐	☐	☐	☐
Talked to someone about how I was feeling	☐	☐	☐	☐
Expressed anger to the person who caused the problem	☐	☐	☐	☐
Tried to get the person responsible to change his or her mind	☐	☐	☐	☐
Realized I had brought the problem on myself	☐	☐	☐	☐
Criticized or lectured myself	☐	☐	☐	☐
Made a promise to myself that things would be different next time	☐	☐	☐	☐
Wished that the situation would go away or somehow be over	☐	☐	☐	☐
I had fantasies about how things might turn out	☐	☐	☐	☐
Tried to lose myself for a while by smoking	☐	☐	☐	☐
Used alcohol to make myself feel better	☐	☐	☐	☐
Consumed cannabis to ease stress	☐	☐	☐	☐
Tried to make myself feel better by eating	☐	☐	☐	☐
Let my feelings out like crying or venting my emotions	☐	☐	☐	☐
Kept others from knowing how bad things were	☐	☐	☐	☐
Didn't let it get to me and refused to think about it too much	☐	☐	☐	☐
Went on as if nothing had happened	☐	☐	☐	☐
Made light of the situation and refused to get too serious about it	☐	☐	☐	☐

Appendix III: Questionnaire C "Experts Survey"

Dear Sir/ Madam,

Invitation to participate in a Doctor of Philosophy (Ph.D.) research on psychological health in the Construction Industry

As a policymaker in the construction industry, you are invited to participate in assisting the construction workplace become psychologically healthy and safe, by completing the attached questionnaire titled "**Improving Psychological Health Among Construction Personnel in Nigeria".** The research is supported by the Department of Building and Real Estate, The Hong Kong Polytechnic University, through a supervisor's grant. The study is under the supervision of Chair Professor Albert P.C. Chan.

The questionnaire and interview session are estimated to take approximately 10 minutes to complete, I plead for your patience. **Kindly respond to the questions based on your expertise and knowledge of the culture within the construction industry**. Please, note that all information provided is strictly for academic purposes and will be treated confidentially in line with the University Human Research Ethical Procedures.

For any enquiries, you can contact the researcher on Tel.: +852-5224 /+234-703456 or email: janet.nwaogu@ .

I am thanking you in anticipation of your support.

Yours sincerely,

…………………………………

Janet M. Nwaogu, Ph.D. Candidate
Department of Building and Real Estate
The Hong Kong Polytechnic University, Hong Kong.

SECTION A: DATA

1) Gender: Male ☐ Female ☐
2) Years of experience in your field of practice.
   a) 6-10yrs ☐ b) 11-20yrs ☐ c) 21-30yrs ☐ d) Over 30yrs ☐
3) Kindly state your profession and professional body affiliation ____________________________

SECTION B: In your opinion, which of the following measures are necessary to help the construction industry **create a psychologically healthy workplace for supervisors**?

(Mark "✔" in the box to best describe your level of agreement to the importance of each strategy).

Measures	**Strongly disagree**	**Disagree**	**Agree**	**Strongly Agree**
Empower staff to be individually more resilient through resilience training programs	☐	☐	☐	☐
Introduce wellness programs to workplaces/site offices	☐	☐	☐	☐
Promote talks about anti-stigma (anti-stigma campaign)	☐	☐	☐	☐
Promote mental health awareness through literacy programmes	☐	☐	☐	☐
Stimulate helping behaviors towards people suffering from mental health problems through literacy programmes such as mental health first aid	☐	☐	☐	☐
Put measures in place for exercises such as exercise weekends or challenge, or going for walks	☐	☐	☐	☐
Provide practical stress management training	☐	☐	☐	☐
Create policies to eliminate bullying	☐	☐	☐	☐
Create policies to eliminate harassment	☐	☐	☐	☐
Promote equality policies irrespective of gender, and age	☐	☐	☐	☐
Promote employees' deeply embedded life interest (i.e., as a supervisor, if an employee's life's interest is mentoring and career building, his or her job roles should include that interest, e.g., anchor retraining or upskilling for subordinates).	☐	☐	☐	☐
Employees should be allowed some flexibility to design their job roles and tasks while, human resources, approves it inline with the job position and goals of the organisation	☐	☐	☐	☐
The workplace should allow site employees' to a flexible work schedule, with regards to work time and duration with no intention to reduce productivity or performance	☐	☐	☐	☐
Put better education policies in place (e.g., providing subsidies for / encouraging employee career development	☐	☐	☐	☐
Reduce threatening of staff with disengagement when they make mistakes	☐	☐	☐	☐
Give constructive feedbacks instead of reprimanding	☐	☐	☐	☐
Ensure swift conflict resolution	☐	☐	☐	☐
Celebrate employee's success	☐	☐	☐	☐
Offer employee's opportunities to balance work and life	☐	☐	☐	☐
Allow the taking of regular breaks to enable rest	☐	☐	☐	☐
Better planning of work tasks and shifts	☐	☐	☐	☐
Hire more personnel to reduce the workload	☐	☐	☐	☐
Conduct employee satisfaction surveys	☐	☐	☐	☐
Conduct regular team meetings with supervisors and tradesmen focused on addressing work stress	☐	☐	☐	☐

Promote communication about work stress from supervisors or tradesmen without penalty	☐	☐	☐	☐
Provide employees with competence training	☐	☐	☐	☐
Supporting improved relationships at work	☐	☐	☐	☐
Put in place measures that increase cooperation between supervisors and subordinates	☐	☐	☐	☐
Offer assistance to non-work stressors such as marital, family or relationship challenges or lifestyle challenges	☐	☐	☐	☐
Provide aid for stressors such as financial challenges	☐	☐	☐	☐
Offer a sustainable retirement plan for employees	☐	☐	☐	☐

Appendix IV: Analysis result on the moderating effect of Resilience

```
Run MATRIX procedure:

**************** PROCESS Procedure for SPSS Version 3.5.2 ****************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2018). www.guilford.com/p/hayes3

**************************************************************************
Model  : 1
    Y  : Alogit
    X  : nCP1
    W  : DicotRES

Sample
Size:  174

**************************************************************************
OUTCOME VARIABLE:
 Alogit

Coding of binary Y for logistic regression analysis:
    Alogit  Analysis
       .00       .00
      1.00      1.00

Model Summary
       -2LL    ModelLL         df          p   McFadden   CoxSnell   Nagelkrk
   122.5892    20.6423     3.0000      .0001      .1441      .1119      .1994

Model
                coeff         se          Z          p       LLCI       ULCI
constant       -.6931      .8660     -.8004      .4235    -2.3905     1.0042
nCP1           -.7985      .9413     -.8483      .3963    -2.6435     1.0465
DicotRES       2.3026     1.3964     1.6489      .0992     -.4344     5.0395
Int_1         -3.2581     1.4855    -2.1932      .0283    -6.1697     -.3465

These results are expressed in a log-odds metric.

Product terms key:
 Int_1    :        nCP1     x        DicotRES

Likelihood ratio test(s) of highest order
unconditional interactions(s):
       Chi-sq         df          p
X*W    5.7393     1.0000      .0166
----------
    Focal predict: nCP1     (X)
          Mod var: DicotRES (W)

Conditional effects of the focal predictor at values of the moderator(s):

   DicotRES     Effect         se          Z          p       LLCI       ULCI
      .0000     -.7985      .9413     -.8483      .3963    -2.6435     1.0465
     1.0000    -4.0566     1.1492    -3.5298      .0004    -6.3091    -1.8042
```

Note: Dependent variable (Y) = Alogit represents Anxiety; Independent variable (X) = nCP1 represents CP1; Moderator (W) = DicotRES represents Resilience

Appendix V: Parameters for System Dynamics Modelling

(01) Content of the job= (Nature of work+Work pressure+Exposure length)-Job demand and satisfaction-Healthy coping and individual resilience

(02) Desiring more job control= -Job control

(03) Desiring more job support= -Job support

(04) Employee Assistance Programme= 1

(05) Employee morale and engagement= 1

(06) Exposure length = WITH LOOKUP (Time,
([(0,0)-(36,20)],(0,0.4),(4,0.8),(8,1.2),(12,1.6),(16,2),(20,2.4),(24,2.8),(28,3.2),(32,3.6),(36,4)))

(07) Exposure period = WITH LOOKUP (Time,
([(0,0)-(36,20)],(0,0.4),(4,0.8),(8,1.2),(12,1.6),(16,2),(20,2.4),(24,2.8),(28,3.2),(32,3.6),(36,4)))

(08) Family related= INTEG (Family related increment, 1.92)
(09) Family related increment= (Marital relationship and challenges+Poor extended family connection or relationships + “Work-life imbalance “+Exposure length-Family related)-Job redesign and control

(10) FINAL TIME = 36
The final time for the simulation.

(11) Healthy coping and individual resilience= 1

(12) High job demand increment= (Content of the job+Workplace bullying-Job demand)-Employee morale and engagement-Job redesign and control

(13) INITIAL TIME = 0
Units: Week
The initial time for the simulation.

(14) Job control= INTEG (Low job control increment, 2.21)

(15) Job demand= INTEG (High job demand increment, 2.44)

(16) Job demand and satisfaction= 1

(17) Job redesign and control= 1

(18) Job support= INTEG (Low job support increment, 2.22)

(19) Low job control increment= ((Little opportunity to participate in decision making+Little task authority+Workplace bullying+Exposure period)+Desiring more job control)-Job redesign and control-Healthy coping and individual resilience

(20) Low job support increment= (Little relationship with colleagues and supervisors+Little social support from colleagues+Exposure period+Desiring more job support)-(Interpersonal relationship)-(Healthy coping and individual resilience) - (Employee morale and engagement)

(21) "Mental ill-health symptoms"= INTEG ("Perceived mental ill-health increment", 4)
Units: Mental Ill-Health

(22) “Perceived mental ill-health increment” = (Family related+Job control+Job demand+Job support+Welfare related+Work hazard related) - Employee Assistance Programme -“Mental ill-health symptoms”.

(23) Poor working conditions= (Lack of medical plan for employees+Lack of subsidies for family travel fees in transfer+No leave or housing allowance+Exposure period)-Employee Assistance Programme

(24) SAVEPER = TIME STEP
The frequency with which output is stored.

(25) TIME STEP = 1
The time step for the simulation.

(26) Welfare related= INTEG (Welfare related increment, 2.14)

(27) Welfare related increment= (Fear of failure+Overpromotion+Poor working conditions+Underpromotion+Unsatisfactory living condition at home+Job insecurity)-Welfare related

(28) Work hazard increment= (Content of the job+Fatigue+Musculoskeletal pain and injuries+ “Occupational injury/hazard”)-Work hazard related

(29) Work hazard related= INTEG (Work hazard increment, 1.99)

(30) Work pressure= Strict adherence to schedule+Workload

(31) “Work-life imbalance” = Content of the job+Little social support from colleagues

(32) Workplace bullying= 1.59-Workplace justice

(33) Workplace justice= 1

Appendix VI: Effect of changes in job demand on mental ill-health symptoms

Time	Simulation output for high job demand			Percentage Change	
	Baseline (no intervention)	25% decrease	25% increase	25% decrease	25% increase
0	4	4	4	0.00	0.00
1	12.92	12.92	12.92	0.00	0.00
2	119.85	94.36	128.43	21.27	7.16
3	120.55	95.06	129.13	21.14	7.12
4	121.25	95.76	129.83	21.02	7.08
5	121.95	96.46	130.53	20.90	7.04
6	122.65	97.16	131.23	20.78	7.00
7	123.35	97.86	131.93	20.66	6.96
8	124.05	98.56	132.63	20.55	6.92
9	124.75	99.26	133.33	20.43	6.88
10	125.45	99.96	134.03	20.32	6.84
11	126.15	100.66	134.73	20.21	6.80
12	126.85	101.36	135.43	20.09	6.76
13	127.55	102.06	136.13	19.98	6.73
14	128.25	102.76	136.83	19.88	6.69
15	128.95	103.46	137.53	19.77	6.65
16	129.65	104.16	138.23	19.66	6.62
17	130.35	104.86	138.93	19.56	6.58
18	131.05	105.56	139.63	19.45	6.55
19	131.75	106.26	140.33	19.35	6.51
20	132.45	106.96	141.03	19.24	6.48
21	133.15	107.66	141.73	19.14	6.44
22	133.85	108.36	142.43	19.04	6.41
23	134.55	109.06	143.13	18.94	6.38
24	135.25	109.76	143.83	18.85	6.34
25	135.95	110.46	144.53	18.75	6.31
26	136.65	111.16	145.23	18.65	6.28
27	137.35	111.86	145.93	18.56	6.25
28	138.05	112.56	146.63	18.46	6.22
29	138.75	113.26	147.33	18.37	6.18
30	139.45	113.96	148.03	18.28	6.15
31	140.15	114.66	148.73	18.19	6.12
32	140.85	115.36	149.43	18.10	6.09
33	141.55	116.06	150.13	18.01	6.06
34	142.25	116.76	150.83	17.92	6.03
35	142.95	117.46	151.53	17.83	6.00
36	143.65	118.16	152.23	17.74	5.97

Appendix VII. Effect of changes in low job control on mental ill-health symptoms

	Simulation output for low job control						Percentage Change		
Time	Baseline (no intervention)	25% decrease	25% increase	50% decrease	50% increase	90% decrease	25% decrease	50% decrease	90% decrease
0	4.00	4.00	4.00	4.00	4.00	4.00	0.00	0.00	0.00
1	12.92	12.92	12.92	12.92	12.92	12.92	0.00	0.00	0.00
2	119.85	118.02	121.68	116.19	123.52	113.25	1.53	3.05	5.50
3	120.55	118.72	122.38	116.89	124.22	113.95	1.52	3.04	5.47
4	121.25	119.42	123.08	117.59	124.92	114.65	1.51	3.02	5.44
5	121.95	120.12	123.78	118.29	125.62	115.35	1.50	3.00	5.41
6	122.65	120.82	124.48	118.99	126.32	116.05	1.49	2.98	5.38
7	123.35	121.52	125.18	119.69	127.02	116.75	1.48	2.97	5.35
8	124.05	122.22	125.88	120.39	127.72	117.45	1.48	2.95	5.32
9	124.75	122.92	126.58	121.09	128.42	118.15	1.47	2.93	5.29
10	125.45	123.62	127.28	121.79	129.12	118.85	1.46	2.92	5.26
11	126.15	124.32	127.98	122.49	129.82	119.55	1.45	2.90	5.23
12	126.85	125.02	128.68	123.19	130.52	120.25	1.44	2.89	5.20
13	127.55	125.72	129.38	123.89	131.22	120.95	1.43	2.87	5.17
14	128.25	126.42	130.08	124.59	131.92	121.65	1.43	2.85	5.14
15	128.95	127.12	130.78	125.29	132.62	122.35	1.42	2.84	5.12
16	129.65	127.82	131.48	125.99	133.32	123.05	1.41	2.82	5.09
17	130.35	128.52	132.18	126.69	134.02	123.75	1.40	2.81	5.06
18	131.05	129.22	132.88	127.39	134.72	124.45	1.40	2.79	5.03
19	131.75	129.92	133.58	128.09	135.42	125.15	1.39	2.78	5.01
20	132.45	130.62	134.28	128.79	136.12	125.85	1.38	2.76	4.98
21	133.15	131.32	134.98	129.49	136.82	126.55	1.37	2.75	4.95
22	133.85	132.02	135.68	130.19	137.52	127.25	1.37	2.73	4.93
23	134.55	132.72	136.38	130.89	138.22	127.95	1.36	2.72	4.90
24	135.25	133.42	137.08	131.59	138.92	128.65	1.35	2.71	4.88
25	135.95	134.12	137.78	132.29	139.62	129.35	1.35	2.69	4.85
26	136.65	134.82	138.48	132.99	140.32	130.05	1.34	2.68	4.83
27	137.35	135.52	139.18	133.69	141.02	130.75	1.33	2.66	4.80
28	138.05	136.22	139.88	134.39	141.72	131.45	1.33	2.65	4.78
29	138.75	136.92	140.58	135.09	142.42	132.15	1.32	2.64	4.75
30	139.45	137.62	141.28	135.79	143.12	132.85	1.31	2.62	4.73
31	140.15	138.32	141.98	136.49	143.82	133.55	1.31	2.61	4.71
32	140.85	139.02	142.68	137.19	144.52	134.25	1.30	2.60	4.68
33	141.55	139.72	143.38	137.89	145.22	134.95	1.29	2.59	4.66
34	142.25	140.42	144.08	138.59	145.92	135.65	1.29	2.57	4.64
35	142.95	141.12	144.78	139.29	146.62	136.35	1.28	2.56	4.61
36	143.65	141.82	145.48	139.99	147.32	137.05	1.27	2.55	4.59

Appendix VIII: Effect of changes in low job support on mental ill-health symptoms

Time	Simulation output for low job support						Percentage Change		
	Baseline (no intervention)	25% decrease	25% increase	50% decrease	50% increase	90% decrease	25% decrease	50% decrease	90% decrease
0	4	4	4	4	4	4.00	0.00	0.00	0.00
1	12.92	12.92	12.92	12.92	12.92	12.92	0.00	0.00	0.00
2	119.85	116.36	123.34	112.88	126.83	107.30	2.91	5.82	10.48
3	120.55	117.06	124.04	113.58	127.53	108.00	2.90	5.78	10.41
4	121.25	117.76	124.74	114.28	128.23	108.70	2.88	5.75	10.35
5	121.95	118.46	125.44	114.98	128.93	109.40	2.86	5.72	10.30
6	122.65	119.16	126.14	115.68	129.63	110.10	2.85	5.68	10.24
7	123.35	119.86	126.84	116.38	130.33	110.80	2.83	5.65	10.18
8	124.05	120.56	127.54	117.08	131.03	111.50	2.81	5.62	10.12
9	124.75	121.26	128.24	117.78	131.73	112.20	2.80	5.59	10.06
10	125.45	121.96	128.94	118.48	132.43	112.90	2.78	5.56	10.01
11	126.15	122.66	129.64	119.18	133.13	113.60	2.77	5.53	9.95
12	126.85	123.36	130.34	119.88	133.83	114.30	2.75	5.49	9.90
13	127.55	124.06	131.04	120.58	134.53	115.00	2.74	5.46	9.84
14	128.25	124.76	131.74	121.28	135.23	115.70	2.72	5.43	9.79
15	128.95	125.46	132.44	121.98	135.93	116.40	2.71	5.41	9.74
16	129.65	126.16	133.14	122.68	136.63	117.10	2.69	5.38	9.68
17	130.35	126.86	133.84	123.38	137.33	117.80	2.68	5.35	9.63
18	131.05	127.56	134.54	124.08	138.03	118.50	2.66	5.32	9.58
19	131.75	128.26	135.24	124.78	138.73	119.20	2.65	5.29	9.53
20	132.45	128.96	135.94	125.48	139.43	119.90	2.63	5.26	9.48
21	133.15	129.66	136.64	126.18	140.13	120.60	2.62	5.23	9.43
22	133.85	130.36	137.34	126.88	140.83	121.30	2.61	5.21	9.38
23	134.55	131.06	138.04	127.58	141.53	122.00	2.59	5.18	9.33
24	135.25	131.76	138.74	128.28	142.23	122.70	2.58	5.15	9.28
25	135.95	132.46	139.44	128.98	142.93	123.40	2.57	5.13	9.24
26	136.65	133.16	140.14	129.68	143.63	124.10	2.55	5.10	9.19
27	137.35	133.86	140.84	130.38	144.33	124.80	2.54	5.07	9.14
28	138.05	134.56	141.54	131.08	145.03	125.50	2.53	5.05	9.09
29	138.75	135.26	142.24	131.78	145.73	126.20	2.52	5.02	9.05
30	139.45	135.96	142.94	132.48	146.43	126.90	2.50	5.00	9.00
31	140.15	136.66	143.64	133.18	147.13	127.60	2.49	4.97	8.96
32	140.85	137.36	144.34	133.88	147.83	128.30	2.48	4.95	8.91
33	141.55	138.06	145.04	134.58	148.53	129.00	2.47	4.92	8.87
34	142.25	138.76	145.74	135.28	149.23	129.70	2.45	4.90	8.83
35	142.95	139.46	146.44	135.98	149.93	130.40	2.44	4.88	8.78
36	143.65	140.16	147.14	136.68	150.63	131.10	2.43	4.85	8.74

Appendix IX: Effect of changes in combined interventions on mental ill-health symptoms

	Simulation output					Percentage Change			
Time	Baseline (no intervention)	Baseline with intervention	All interventions 200%	Primary + Secondary intervention	Primary + Secondary (200% increase)	With intervention	Primary + secondary	Primary + Secondary (200% increase)	All intervention 200%
0	4	4	4	4	4	0.00	0.00	0.00	0.00
1	12.92	12.92	12.92	12.92	12.92	0.00	0.00	0.00	0.00
2	119.85	102.85	85.85	103.85	86.85	14.18	13.35	27.53	28.37
3	120.55	103.55	86.55	104.55	87.55	14.10	13.27	27.37	28.20
4	121.25	104.25	87.25	105.25	88.25	14.02	13.20	27.22	28.04
5	121.95	104.95	87.95	105.95	88.95	13.94	13.12	27.06	27.88
6	122.65	105.65	88.65	106.65	89.65	13.86	13.05	26.91	27.72
7	123.35	106.35	89.35	107.35	90.35	13.78	12.97	26.75	27.56
8	124.05	107.05	90.05	108.05	91.05	13.70	12.90	26.60	27.41
9	124.75	107.75	90.75	108.75	91.75	13.63	12.83	26.45	27.25
10	125.45	108.45	91.45	109.45	92.45	13.55	12.75	26.31	27.10
11	126.15	109.15	92.15	110.15	93.15	13.48	12.68	26.16	26.95
12	126.85	109.85	92.85	110.85	93.85	13.40	12.61	26.01	26.80
13	127.55	110.55	93.55	111.55	94.55	13.33	12.54	25.87	26.66
14	128.25	111.25	94.25	112.25	95.25	13.26	12.48	25.73	26.51
15	128.95	111.95	94.95	112.95	95.95	13.18	12.41	25.59	26.37
16	129.65	112.65	95.65	113.65	96.65	13.11	12.34	25.45	26.22
17	130.35	113.35	96.35	114.35	97.35	13.04	12.27	25.32	26.08
18	131.05	114.05	97.05	115.05	98.05	12.97	12.21	25.18	25.94
19	131.75	114.75	97.75	115.75	98.75	12.90	12.14	25.05	25.81
20	132.45	115.45	98.45	116.45	99.45	12.84	12.08	24.92	25.67
21	133.15	116.15	99.15	117.15	100.15	12.77	12.02	24.78	25.54
22	133.85	116.85	99.85	117.85	100.85	12.70	11.95	24.65	25.40
23	134.55	117.55	100.55	118.55	101.55	12.63	11.89	24.53	25.27
24	135.25	118.25	101.25	119.25	102.25	12.57	11.83	24.40	25.14
25	135.95	118.95	101.95	119.95	102.95	12.50	11.77	24.27	25.01
26	136.65	119.65	102.65	120.65	103.65	12.44	11.71	24.15	24.88
27	137.35	120.35	103.35	121.35	104.35	12.38	11.65	24.03	24.75
28	138.05	121.05	104.05	122.05	105.05	12.31	11.59	23.90	24.63
29	138.75	121.75	104.75	122.75	105.75	12.25	11.53	23.78	24.50
30	139.45	122.45	105.45	123.45	106.45	12.19	11.47	23.66	24.38
31	140.15	123.15	106.15	124.15	107.15	12.13	11.42	23.55	24.26
32	140.85	123.85	106.85	124.85	107.85	12.07	11.36	23.43	24.14
33	141.55	124.55	107.55	125.55	108.55	12.01	11.30	23.31	24.02
34	142.25	125.25	108.25	126.25	109.25	11.95	11.25	23.20	23.90
35	142.95	125.95	108.95	126.95	109.95	11.89	11.19	23.08	23.78
36	143.65	126.65	109.65	127.65	110.65	11.83	11.14	22.97	23.67

Appendix X: Effect of changes in single interventions on mental ill-health symptoms

	Simulation output							Percentage Change				
Time	Baseline (no intervention)	Baseline with intervention	All interventions 200%	Primary intervention	Primary interventions 200%	Secondary interventions	Secondary 200%	With intervention	Primary	Primary interventions 200%	Secondary interventions	Secondary 200%
0	4	4	4	4	4	4	4	0.00	0.00	0.00	0.00	0
1	12.92	12.92	12.92	12.92	12.92	12.92	12.92	0.00	0.00	0.00	0.00	0.00
2	119.85	102.85	85.85	111.85	103.85	114.85	109.85	14.18	6.68	13.35	4.17	8.34
3	120.55	103.55	86.55	112.55	104.55	115.55	110.55	14.10	6.64	13.27	4.15	8.30
4	121.25	104.25	87.25	113.25	105.25	116.25	111.25	14.02	6.60	13.20	4.12	8.25
5	121.95	104.95	87.95	113.95	105.95	116.95	111.95	13.94	6.56	13.12	4.10	8.20
6	122.65	105.65	88.65	114.65	106.65	117.65	112.65	13.86	6.52	13.05	4.08	8.15
7	123.35	106.35	89.35	115.35	107.35	118.35	113.35	13.78	6.49	12.97	4.05	8.11
8	124.05	107.05	90.05	116.05	108.05	119.05	114.05	13.70	6.45	12.90	4.03	8.06
9	124.75	107.75	90.75	116.75	108.75	119.75	114.75	13.63	6.41	12.83	4.01	8.02
10	125.45	108.45	91.45	117.45	109.45	120.45	115.45	13.55	6.38	12.75	3.99	7.97
11	126.15	109.15	92.15	118.15	110.15	121.15	116.15	13.48	6.34	12.68	3.96	7.93
12	126.85	109.85	92.85	118.85	110.85	121.85	116.85	13.40	6.31	12.61	3.94	7.88
13	127.55	110.55	93.55	119.55	111.55	122.55	117.55	13.33	6.27	12.54	3.92	7.84
14	128.25	111.25	94.25	120.25	112.25	123.25	118.25	13.26	6.24	12.48	3.90	7.80
15	128.95	111.95	94.95	120.95	112.95	123.95	118.95	13.18	6.20	12.41	3.88	7.75
16	129.65	112.65	95.65	121.65	113.65	124.65	119.65	13.11	6.17	12.34	3.86	7.71
17	130.35	113.35	96.35	122.35	114.35	125.35	120.35	13.04	6.14	12.27	3.84	7.67
18	131.05	114.05	97.05	123.05	115.05	126.05	121.05	12.97	6.10	12.21	3.82	7.63
19	131.75	114.75	97.75	123.75	115.75	126.75	121.75	12.90	6.07	12.14	3.80	7.59
20	132.45	115.45	98.45	124.45	116.45	127.45	122.45	12.84	6.04	12.08	3.78	7.55
21	133.15	116.15	99.15	125.15	117.15	128.15	123.15	12.77	6.01	12.02	3.76	7.51
22	133.85	116.85	99.85	125.85	117.85	128.85	123.85	12.70	5.98	11.95	3.74	7.47
23	134.55	117.55	100.55	126.55	118.55	129.55	124.55	12.63	5.95	11.89	3.72	7.43
24	135.25	118.25	101.25	127.25	119.25	130.25	125.25	12.57	5.91	11.83	3.70	7.39
25	135.95	118.95	101.95	127.95	119.95	130.95	125.95	12.50	5.88	11.77	3.68	7.36
26	136.65	119.65	102.65	128.65	120.65	131.65	126.65	12.44	5.85	11.71	3.66	7.32
27	137.35	120.35	103.35	129.35	121.35	132.35	127.35	12.38	5.82	11.65	3.64	7.28
28	138.05	121.05	104.05	130.05	122.05	133.05	128.05	12.31	5.80	11.59	3.62	7.24
29	138.75	121.75	104.75	130.75	122.75	133.75	128.75	12.25	5.77	11.53	3.60	7.21
30	139.45	122.45	105.45	131.45	123.45	134.45	129.45	12.19	5.74	11.47	3.59	7.17
31	140.15	123.15	106.15	132.15	124.15	135.15	130.15	12.13	5.71	11.42	3.57	7.14
32	140.85	123.85	106.85	132.85	124.85	135.85	130.85	12.07	5.68	11.36	3.55	7.10
33	141.55	124.55	107.55	133.55	125.55	136.55	131.55	12.01	5.65	11.30	3.53	7.06
34	142.25	125.25	108.25	134.25	126.25	137.25	132.25	11.95	5.62	11.25	3.51	7.03
35	142.95	125.95	108.95	134.95	126.95	137.95	132.95	11.89	5.60	11.19	3.50	7.00
36	143.65	126.65	109.65	135.65	127.65	138.65	133.65	11.83	5.57	11.14	3.48	6.96

Appendix XI: Validation Questionnaire

Q) Based on the research results provided to you, kindly indicate your response to the questions in the table using the agreement scale.

(Mark "✔" in the box to best describe your level of agreement).

Validation Statements	***Strongly disagree***	***Disagree***	***Agree***	***Strongly Agree***
The risk factors and their constructs are reasonable	☐	☐	☐	☐
The protective factors are appropriate	☐	☐	☐	☐
The strategies within the strategy constructs are appropriate	☐	☐	☐	☐
The integrated mental health promotion framework is understandable	☐	☐	☐	☐
The integrated mental health promotion is suitable for mental health promotion in the Nigerian construction industry	☐	☐	☐	☐
The integration of sleep management training into the final framework is understandable and reasonable	☐	☐	☐	☐
The total sleep time to sleep score is useful for promoting adequate recovery following work stress				

Appendix XII: Approval for Ethical Approval

THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

To	Chan Ping Chuen (Department of Building and Real Estate)
From	Ni Meng, Chair, Departmental Research Committee
Email	meng.ni@ Date 16-Sep-2019

Application for Ethical Review for Teaching/Research Involving Human Subjects

I write to inform you that approval has been given to your application for human subjects ethics review of the following project for a period from 07-Oct-2019 to 30-Aug-2021:

Project Title:	Determining the impact of work pressure/load on the physiological health of the construction personnel
Department:	Department of Building and Real Estate
Principal Investigator:	Chan Ping Chuen
Project Start Date:	07-Oct-2019
Reference Number:	HSEARS20190916001

You will be held responsible for the ethical approval granted for the project and the ethical conduct of the personnel involved in the project. In case the Co-PI, if any, has also obtained ethical approval for the project, the Co-PI will also assume the responsibility in respect of the ethical approval (in relation to the areas of expertise of respective Co-PI in accordance with the stipulations given by the approving authority).

You are responsible for informing the Human Subjects Ethics Sub-committee in advance of any changes in the proposal or procedures which may affect the validity of this ethical approval.

Ni Meng

Chair

Departmental Research Committee (on behalf of Human Subjects Ethics Sub-Committee)

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