The Role of Human Safety Interventions on Co-Workers' Safety Outcomes in Construction Projects

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Environmental and Occupational Health at the University of Newcastle

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STATEMENT OF ORIGINALITY

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By signing below I confirm that Emmanuel Bannor Boateng contributed conceptualisation, methodology, formal analysis and writing to the publications entitled below

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Manikam Pillay

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Dr Manikam Pillay

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DEDICATION

And for whom, anyway, do I do the things that lead to a PhD

if not for my mother, Mercy

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LIST OF ABBREVIATIONS

ARS	Audience Response System
AWHSS	Australian Work Health and Safety Strategy
AVE	Average Variance Extracted
BBS	Behaviour-Based Safety
R^2	Coefficient of Determination
CFI	Comparative Fit Index
CR	Composite Reliability
CFA	Confirmatory Factor Analysis
CB-SEM	Covariance-Based Structural Equation Modelling
rho_A	DiJkstra-Henseler's rho
EFA	Exploratory Factor Analysis
HTMT	Heterotrait-Monotrait Ratio
HREC	Human Research Ethics Committee
HSI	Human Safety Interventions
KMO	Kaiser-Meyer-Olkin
MLE	Maximum Likelihood Estimation
MaxR(H)	Maximum Reliability(H)
MSV	Maximum Shared Variance
MICE	Multivariate Imputation by Chained Equations
OHS	Occupational Health and Safety
PClose	*p* of close fit
PLS-SEM	Partial Least Squares-Structural Equation Modelling
PPE	Personal Protective Equipment
RMSEA	Root Mean Squared Error of Approximation
SRMR	Standardised Root Mean Squared Residual
SEM	Structural Equation Modelling
VB-SEM	Variance-Based Structural Equation Modelling

ABSTRACT

Globally, the construction industry is known to have a high rate of recorded accidents, fatalities, or injuries. Historically, the behaviour of workers concerning safety matters was recognised as a significant factor leading to poor safety outcomes. Recently, insights from assessing workers' safety climate have been used to improve workers' safety. These insights often tend to focus on a worker's perception about the leadership and/or self rather than the workgroup within which one operates. Considering the physical and social proximity of construction activities, the lack of attention on social and team practices, which are vital to construction activities, has resulted in challenges to accident reduction rates. Despite this, there is a limited body of knowledge on factors that influence workers' perceptions, especially in the workgroup among co-workers. Owing to this, safety interventions have been suggested as possible antecedents that improve safety climate. Hence, this research aims to investigate how human safety interventions (HSIs) affect workgroup safety climate and co-workers' safety behaviour.

A quantitative approach employing a strategy using a cross-sectional survey collected data from 317 trade workers within five large commercial construction projects in New South Wales, Australia. Exploratory factor analysis, reliability analysis, descriptive statistics, and covariance-based structural equation modelling were used to develop and validate the HSI constructs. Following this, variance-based structural equation modelling was used to validate the theoretical model by evaluating thirteen proposed hypotheses. Due to the complexity of the model, another model was further developed to examine how co-workers' safety outcomes influence workers' perceptions about safety priority.

Results from validating the HSI construct revealed two factors: psychological safety interventions and sociological safety interventions. An intersection was found between the two factors suggesting that they should be regarded as reflective-reflective higher-order constructs. Because the two factors tap into the same underlying concept. Thirteen out of the fourteen hypotheses were supported. The results suggest that HSIs do not directly influence co-workers' safety behaviour. Instead, an increase in HSIs strengthens the relationship between how workers' perceived the value of safety and co-workers' safety behaviour. The study shows that, through social exchanges, the provision

of HSIs positively improves workgroup safety climate. The relationship between supervisory environment and workgroup safety climate was strengthened by HSIs. A partial mediation was revealed, as the supervisory environment influences the workgroup safety climate through HSIs. An increase in safety outcomes was found to decrease the workgroup safety climate. The study also identified a route to reducing the number of accidents and near-misses on construction sites.

The implication of the research is that it identifies supervisory environment, co-workers' safety outcomes and HSIs as factors influencing the perceptions workers' form about the priority of safety in their organisation. These outcomes contribute to the expansion of the safety climate theory in construction. The study confirms the role HSIs play in reducing risks and uncertainties while improving workers' safety knowledge and reasoning. The implementation of HSIs by construction managers or safety professionals offers a fertile ground for the formation of workgroup safety climate. The study also stresses the need for a focus on co-workers as they are important agents of change in the development of safety perceptions by other workers. In addition, the research contributes to the development and validation of the HSI construct in construction. The validated HSI scale may be used to identify potential weaknesses within existing construction safety regimes. The scale has the potential, alongside other established safety constructs to function as a modifying factor in cultivating desired behaviours. The research also contributes to the categorisation of safety climate dimensions at various levels of climate analysis. Finally, the study provides implications for practice and recommendations for further study.

1 INTRODUCTION

1.1 Background

Working in the construction industry is extremely dangerous (Loosemore, Sunindijo & Zhang 2020). According to a recent report by the International Labour Organisation (2020), the industry has an extremely high proportion of recorded accidents. Similarly, the latest release by the Australian Bureau of Statistics (2018) shows that “construction had the highest work-related injury or illness (59 per 1000 employed persons)” in Australia. Considering that the rate of technological errors in the industry has lessened, the role of human behaviour has become more palpable (Scott, Fleming & Kelloway 2014). Unsafe behaviour by workers at the workplace can cause accidents, fatalities, or injuries, as well as incur significant costs and the loss of corporate reputations (Sing et al. 2014). Statistics show that not less than 80% of fatal incidents may be associated with the acts and neglects of people (Health and Safety Executive 2009). Safety experts such as Lingard & Rowlinson (2004); Sunindijo, Zou & Dainty (2017) put this percentage even higher, positing a range of 80-90% of all fatal incidents are fuelled by inappropriate behaviour of employees. Such undesirable behaviour by workers is an enduring managerial conundrum affecting many jobs (Zohar & Erev 2007).

An efficient way to suppress accident rates and improve hazard management is to enhance the social and organisational factors that influence safety (Lee 1995; Scott, Fleming & Kelloway 2014). This has encouraged researchers and practitioners to focus on these aspects, including the safety climate, to encourage positive change in the industry’s and to improve its’ poor safety performance (Lingard, Cooke & Blismas 2010b). Safety climate is an outcome of employee perceptions formed from a deliberate emphasis on performance within high-risk tasks (Zohar 2000). A positive safety climate is associated with substantial benefits, such as growth in production, improved worker safety knowledge, a tendency to behave safely, cuts in worker incident numbers, and increased implementation of safety-related policies and programs (Loosemore et al. 2019a; WorkCover Queensland 2019). Thus, a higher safety climate score indicates a stronger future safety performance and behaviour (Lingard, Cooke & Blismas 2012; Zhang, Lingard & Nevin 2015).

The relationship between safety climate and safety behaviour, and its effects on safety outcomes/performance, has been well established in the literature. The underlying linkages among these concepts could be explained through social exchange theory and expectancy-valence theory (Neal & Griffin 2006; Zohar 2008). For instance, when individuals perceive that their organisation values their welfare, they will cultivate an inherent commitment to give back by choosing a behaviour that benefits their organisation (Neal & Griffin 2006). Therefore, organisations can form an atmosphere of safety by caring for their workers.

On the other hand, empirical findings from a recent longitudinal study (data ranging from 2001 to 2013) give partial support to the notion of utilising safety climate as a predictor of future safety outcomes (cf. Gilberg et al. 2015). Likewise, studies such as Glendon & Litherland (2001) in the construction industry revealed no relationship between safety climate and safety behaviour. Further, meta-analytic evidence by Clarke (2006b) found a weak correlation between safety climate and safety outcomes, such as accidents and injuries. As such, the climate-behaviour-accident route is not as straightforward as usually presumed (Cooper & Phillips 2004).

While considerable research has sought to study the influence of safety climate on safety performance and outcomes, few studies have investigated how climate perceptions are formed in construction. Put simply, what is that predicts safety climate in construction? Some of the few studies that have investigated climate formation in construction have identified communication network density (Lingard, Pirzadeh & Oswald 2019), psychological contract (Newaz et al. 2019b), and social identity (Andersen et al. 2018) as antecedents of safety climate. In this regard, how construction employee perception is developed remains less understood (Lingard, Pirzadeh & Oswald 2019; Newaz et al. 2019b).

Given these factors, Zohar (2014) comments that it is time to proceed to the next chapter of research, where the safety climate concept is improved by examining its associations with antecedents, moderators and mediators, and, in addition, its link with other established constructs. Similar calls had earlier been made in behavioural safety research by Krispin & Hantula (1996). There is a need to institute interventions that adjust the value utility for safety behaviour (Zohar & Erev 2007). However, no suitable research has been recognised in terms of interventions for a better safety climate (Huang, Chen & Grosch 2010). There is, therefore, a dearth of safety climate studies testing intervention strategies intended to improve the safety climate in construction (Zohar 2014). Consequently, there is a need to identify interventions that aim at augmenting safety climates (Huang, Chen & Grosch 2010) as a means to ameliorate the link between safety climate and safety behaviour (Boateng, Davis & Pillay 2020).

Considering the need to focus on more social and organisational factors, human safety interventions (HSIs) can go a long way toward minimising accidents, as they offer mediums for social learning and multiple social interactions among co-workers and their immediate physical and social environment. HSIs denote methods to change human understanding and reasoning concerning safety practices that directly impact the employee (Robson et al. 2001; Shakioye & Haight 2010; Zaira & Hadikusumo 2017). From the Prospect theory view, the practices of HSIs, such as safety incentives, would help workers overcome the propensity to under weigh the future benefits of safe behaviour (Zohar & Erev 2007; Zohar & Luria 2003). Hence, the formation of a positive safety climate involves effort and safety-related interventions (Cheung & Zhang 2020). Given this, the study aims to investigate the role of HSIs in reducing poor safety outcomes through workers safety perceptions and behaviour.

1.2 Research Gap

Unlike industries such as transportation (e.g. lone workers, such as long-haul truck drivers) where the psychological safety climate plays a greater role (cf. Zohar et al. 2014), the nature of other industries such as manufacturing, construction, and health-care, includes daily possibilities for social interaction with co-workers, supervisors and top management (Lingard, Cooke & Blismas 2010a; Zohar et al. 2014). While shared perceptions are a key attribute of the safety climate, the lack of shared perceptions connotes the absence of group and organisational climates (James et al. 2008). This distinction of climate as a trait of the group or organisation has been a key step for climate studies, although some scholars still investigate climate at the individual level (Schneider, Ehrhart & Macey 2013). A large volume of empirical studies have examined the influence that the psychological safety climate has on safety outcomes/performance at the individual level (Clarke 2006b; Shen et al. 2015). While much of the safety climate studies have focused on the organisation level of analysis (Andersen et al. 2018; Lingard, Cooke & Blismas 2011; Newaz et al. 2018). As a result, there is a need for studies at the group level (cf. Cooke, Lingard & Blismas 2013), since group safety climates have a higher propensity to emerge in decentralised organisations, such as in construction (Lingard, Cooke & Blismas 2009; Newaz et al. 2018).

In addition, convincing evidence from psychology stresses the need to study the effect of co-workers on a group safety climate (e.g. Ashforth 1985; Bandura 1986). According to Schneider (1987), co-workers are not just a crucial component of the social setting at the workplace, they actually define it. Despite the relevance of co-worker influence, research at the group level of safety climate is inclined to forget the function of co-workers and direct much effort to workers' perceptions of supervisory leadership to denote the group safety climate (Brondino, Silva & Pasini 2012; Lingard, Cooke & Blismas 2009). The group safety climate should be extended to embrace co-workers. Given these discussions, the causal influences of co-workers are not well comprehended in construction (Schwatka & Rosecrance 2016). Considering that construction workers are more socially proximal to their co-workers than other agents, studies are required to go beyond the leadership-worker relationship (e.g. Newaz et al. 2019a), to augment the safety climate theory (Zohar 2010). This would broaden the understanding of how co-workers play their part as important agents of change in sharing and agreeing on views concerning safety.

Very few studies in construction have sought to unravel the factors contributing to the formation of workers' perceptions about the priority of safety, which could, in turn, minimise accidents. However, the reverse could also be valid, e.g. when accidents/injuries and near misses occur on the construction site, do they affect the perceptions that workers form about the priority of safety in their organisation? This question is important because the outcomes of climate perceptions can in turn serve as predictors of climate (Schneider et al. 2017; Schneider, White & Paul 1998). From social information processing theory (Salancik & Pfeffer 1978), it may be inferred that the frequent occurrence of accidents informs and affects workers' interpretations of the prevailing conditions and how an organisation prioritises safety. Importantly, while most of the studies have focused on examining how safety climate perceptions influence safety outcomes, no study has yet to investigate the reverse in construction.

As highlighted in the Background section (Section 1.1), HSIs could improve the safety perceptions workers form about their organisation. Also, instituting these interventions could result in a decline in accident rates and associated costs (Cooper 1998). This research aims to fill these gaps and reflect on the aforementioned areas by exploring how HSIs affect the workgroup safety climate and co-workers' safety behaviour. It places HSIs as providing a fertile ground for climate emergence. The study also examines the ability of the prevailing safety outcomes to influence the workers' perceptions about the value of safety. Given these linkages, the study employs a multilevel approach by assessing workers perceptions about management, supervisors, the immediate physical environment and, most importantly, their co-workers. This would provide a clearer picture of workers' views on safety throughout the organisation and help examine the role of HSIs on co-workers' safety outcomes such as accidents/injuries and near misses. Considering HSIs as an emerging construct, the study further strengthens its conceptualisation and develops and validates the construct within the Australian context.

1.3 Research Aim

This thesis aims to investigate the effect of HSIs on the impact of workgroup safety climate and on co-workers' safety behaviour in construction projects.

1.4 Research Question

Considering the aim, this research seeks to answer the question, "How do HSIs influence the impact of workgroup safety climate on co-workers' safety behaviour in construction projects?"

1.5 Research Objectives

The following objectives were developed to achieve the aim:

1. To review literature linked with the key concepts of safety climate, safety behaviour, and safety outcomes.
2. To create a theoretical model of the role of HSIs in workgroup safety climate and its effect on co-workers' safety behaviour in construction projects.
3. To develop and validate the construct of HSIs in construction projects.
4. To examine the influence of HSIs on the relationship between workgroup safety climate and co-workers' safety outcomes in construction projects.
5. To examine how co-workers' safety outcomes predict workgroup safety climate perceptions in construction projects.

1.6 Significance of the Study

This thesis contributes to the expansion of safety climate theory in the construction industry. The theory proposes that, at a given time, workers form perceptions about the value and priority of safety within their organisation. These perceptions are important because they predict safety performance. As such, considerable research has made significant contributions to this safety climate and performance association. However, very few studies in construction have investigated how climate perceptions are formed (cf. Andersen et al. 2018; Lingard, Pirzadeh & Oswald 2019; Newaz et al. 2019a, 2019b). This area of study is relevant because the ability to influence these perceptions would further affect safety outcomes. In contributing to this niche area of study, this thesis proposes HSIs, the supervisory environment, and co-workers' safety outcomes as predictors of workgroup safety climate.

The thesis also contributes to the development and validation of the HSI construct in construction. The HSI scale, when validated, could be used for monitoring and diagnosis of potential weaknesses in safety practices by construction managers and supervisors. Considering the call for a next-level investigation into safety climate research (Zohar 2010, 2014), HSIs could be examined with safety climate and other established constructs as mediators, moderators, and antecedents to form a route to cultivating desired behaviours.

1.7 Chapter Summary

Chapter One introduced the background to the study and highlighted the research gap. It proposed HSIs as approaches that provide a platform for workers to form positive perceptions about the value of safety within their organisation. The chapter also presented the research objectives necessary for addressing the research question. The significance of the study was highlighted. The next chapter (Chapter Two) includes a review of the pertinent literature including concepts such as safety climate, safety behaviour, safety outcomes, and human safety interventions. The chapter provides key historical, current, and theoretical evidence governing this research. It also presents the research model. The chapter argues for the need for a safety intervention to strengthen the link between safety climate and safety behaviour. Chapter Three discusses the body of methods and principles influencing the research. The outlines the procedures for undertaking the research. It selects an appropriate worldview needed to address the research question. Chapter Four includes data analyses and results. The chapter provides the demographic features of the sample, develops, and validates the HSI construct, and gives empirical evidence about the validity of the research model. Chapter Five discusses the results obtained from the data analyses. It elaborates on the validated HSI scale and gives reasons as to why certain hypotheses were accepted and others were rejected.

Finally, Chapter Six concludes the study and suggests further research needs. The chapter also highlights the contributions and limitations of the study.

2 LITERATURE REVIEW

2.1 Introduction

This section discusses the literature on safety climate, safety behaviour, safety outcomes, and human safety interventions (HSIs). Theories on which these concepts are based are highlighted. Earlier and ongoing debates concerning these concepts, their associations and developments are stressed. Afterwards, the initial hypotheses are presented. To achieve these, first, the study is conceptualised within the Australian construction industry. It presents the current state of safety within the industry, hence the need for safety climate. A brief history and scholarly definitions of safety climate are provided, then the relevance of safety climate is discussed. Considering the hierarchical nature of construction organisations, the chapter further conceptualises the level of safety climate analysis and highlights the need for multilevel analysis of climate perceptions. A case is then made for a need to focus on the group and organisational level of analysis. After establishing the level of perceptual analysis for the study, co-workers are integrated into the group safety climate as an important agent of change. Various approaches for measuring safety climate are then appraised.

Next, the constituents of the group and organisational safety climates are examined and theorised, and a framework is developed to summarise the discussions concerning these facets. An overview of safety behaviour is provided. Safety behaviour and safety outcomes are then distinguished while discussing various aspects of safety behaviour. Different measures of safety performance are deliberated upon to select a suitable measure for the study. In conclusion, theories underlying the association among safety climate, safety behaviour and safety outcomes are highlighted and further supported with existing empirical evidence. This leads to the initial study hypotheses.

Afterwards, the chapter presents the research model. The purpose of the research model is to provide a theoretical understanding of the role of HSIs in workgroup safety climate and its effect on co-workers' safety behaviour in construction projects. This would help to provide insights on how HSIs could reduce poor safety outcomes through workers safety perceptions and behaviour. The chapter identifies various gaps in the literature and sets out to develop the research hypotheses. This chapter argues for the need for a safety intervention to strengthen the link between safety climate and behaviour. It then proceeds to provide determination and definitions of existing safety interventions and their practices. Two factors are presented as criteria for selecting an intervention; namely, national culture and decision making under risk and uncertainty. The HSI is then selected based on these two considerations. A preliminary measure for this intervention is then discussed. Next, associations among the HSI practices are theoretically examined, this leads to the development of the research model. Due to the complexity of the preliminary model, another model is developed that explores how poor safety outcomes influence upon a workers' safety perception.

2.2 Safety in the Australian Construction Industry

The construction industry in Australia is one of the most significant industries with respect to its contribution to the economy and influence on occupational health and safety (OHS) (Davis et al. 2016; Lingard & Rowlinson 2004). From 2011 to 2012, businesses in the industry added a total value of $99.4bn (Australian Bureau of Statistics 2013). Between 2013 and 2014, the industry employed 9% of the working population (Safe Work Australia 2015a). According to the Department of Jobs and Small Business (2018), the employment rate in the industry is projected to increase by 10% over the next five years to May 2023, indicating strong infrastructure investment and high levels of building activities.

Currently, the safety of construction in Australia has been of concern, with poor OHS leading to an estimated cost of $5.84bn from 2012 to 2013, being approximately 10% of the total cost of work-related injury and illness (Loosemore et al. 2019a; Safe Work Australia 2015b). This is because, for some time, the industry has had a comparatively high rate of accidents and serious claims (Boateng, Davis & Pillay 2020). For instance, over the last five years construction ranked third in both the number of fatalities and serious claims among 19 industries (Safe Work Australia 2018). While the number of fatalities and serious claims over the last 10 years continued to be relatively high, there have been significant advancements (Safe Work Australia 2018). These developments include the formulation of the Australian Work Health and Safety Strategy (AWHSS) 2012-2022, which was geared towards reducing the number of occupational fatalities and injuries. The AWHSS identified the construction industry as a national priority to focus their efforts on the prevention and reduction of the industry's high numbers of fatalities.

Regardless of these improvements, the construction sector continues to be a high-risk industry (Hallowell, Bhandari & Alruqi 2020; Hatami et al. 2017; Renecle et al. 2021; Safe Work Australia 2015a). For instance, implementation of the AWHSS brought a decline in the number of fatalities in the initial year (2013), yet the subsequent years have shown a chronic increase in the number of fatalities on construction sites. Currently, Safe Work Australia (2019) statistics show that 35 construction workers are seriously injured each day in Australia. Reducing the number of accidents and fatalities necessitates a thorough understanding of how accidents are caused (Pillay 2015). This insight would help prevent future accidents through the effective planning and implementation of focused interventions.

Data-driven investigations show that as many as 90% of all accidents are caused by human errors (Sunindijo, Zou & Dainty 2017). Lingard & Rowlinson (2004) further concluded that inappropriate behaviour precedes 80-90% of all fatal incidents. Since the rate of technological errors in the industry has lessened, the role of human behaviour has become more palpable (Scott, Fleming & Kelloway 2014). In effect, inappropriate behaviour by workers is an ongoing managerial challenge affecting many jobs (Zohar & Erev 2007). Thus, employee behaviour is a significant component of OHS. Essentially, a viable means to suppress accident rates and improve hazard management is to enhance the social and organisational factors that influence OHS (Lee 1995; Scott, Fleming & Kelloway 2014), and to address the hearts and minds of the employers and employees (Lee 1998). This has led researchers and practitioners to focus on organisational and social factors, including safety climate, to encourage positive change in the industry's poor OHS performance (Le et al. 2021; Lingard, Cooke & Blismas 2010b).

In particular, a focus on safety climate minimises the number of occupational accidents, improves employee motivation to behave safely, and reduces compensation costs (Loosemore et al. 2019a; WorkCover Queensland 2019). As such, safety climate has become a significant cornerstone of OHS management (Fugas, Silva & Meliá 2012; Loh et al. 2019; Pandit, Albert & Patil 2020). Consistent with these developments in OHS, the thesis of this research follows the safety climate theory for advancing OHS. This theory is relevant for this study because it assumes that workers form shared perceptions about the value of safety in their organisation (Zohar 1980). As will be detailed in later sections, these consensual views concerning the priority of safety influence safety outcomes such as accidents/injuries and near misses. In the quest to strive for a more thorough understanding of the theory, a vignette of the beginnings of safety climate and associated scholarly definitions are presented in the next section.

2.3 Safety Climate: Origin and Definition

In this section, a brief outline of the genesis of safety climate is provided and various definitions of safety climate are explored. The concept of safety climate emerged from organisational climate theory (Schneider 1975). Before the 1970s, Lewin, Lippitt & White (1939) originally used the term “social climate” to symbolise a group-centred atmosphere formed by adult leaders of children clubs. In general, “organisational climate” refers to shared perceptions among individuals in an organisation concerning policies, procedures, and practices (Ostroff, Kinicki & Tamkins 2003; Reichers & Schneider 1990; Schneider et al. 2017). It encompasses the meanings employees ascribe to a colligated collection of experiences they have at work (Schneider, Ehrhart & Macey 2013). These perceptions and meanings guide employees’ actions by relaying to them the behaviour that is desirable or expected in the organisation (Ajzen 1980; Al-Kurdi, El-Haddadeh & Eldabi 2020; Zohar & Erev 2007). In sum, the bandwidth and focus of organisational climate capture a more psychological view of the workplace. Organisational climate is, therefore, a fundamental instrument for building discretionary employee behaviour (Marinova, Cao & Park 2019; Schneider, Ehrhart & Macey 2013).

During the 1971-1985 era of organisational climate research, also termed “feeling the elephant”, various researchers sought to examine how to quantify climate, as well as its relation to other specific concepts, variables or constructs (Schneider et al. 2017). At this stage, to sharpen the focus of climate studies, Schneider (1975) reasoned the need for a climate “for something”, as such an endeavour gave way to research investigations with credible validity evidence. According to Schneider et al. (2017), not only do focused climate studies yield a robust validity, they also provide insights into the frameworks that are likely to produce these focused climates. Moreover, the identification of specific facets of climate provides differentiation within the summary of employee perceptions, along with succinct descriptive features within the organisation. It is within this period that Zohar (1980) developed the concept of safety climate. Inspired by the multidimensional construct, i.e. organisational climate (James & James 1989), a specific form of climate – climate for safety – was created (Neal, Griffin & Hart 2000; Zohar 1980). In the original safety climate study, Zohar (1980) measured the perceptions of production workers regarding various facets of occupational safety in a variety of industries and found that there is consensus among workers' perceptions concerning safety in their organisations. Since then, numerous studies have been conducted while propagating various metaphors and definitions for the term "safety climate".

According to Zohar (2000), safety climate is an outcome of employee perceptions, formed from a deliberate emphasis on performance within high-risk tasks. The concept assumes that industrial workers have coherent sets of perceptions concerning aspects of their organisation (Zohar 1980, 2010). At its core, safety climate reveals the surface level meanings related to safety, instead of the true culture of safety (Loosemore et al. 2019a; Oswald et al. 2018). Zohar (1980, p. 96) first defined safety climate as "a summary of molar perceptions that employees share about their work environments". Huang, Chen & Grosch (2010, p. 1421) also refer to safety climate as "the workers' perceptions or the organisation's policies, procedures, and practices as they relate to the value, importance, and actual priority of safety within the organisation". According to Niskanen (1994, p. 241), safety climate is "a set of attributes that can be perceived about particular work organisations and which may be induced by the policies and practices that those organisations impose upon their workers and supervisors". Lingard, Cooke & Blismas (2010b, p. 814) refer to safety climate as "perceptions of what is actually done, thus it is the check of whether the behaviour of people in the organisation matches the rhetoric". Neal, Griffin & Hart (2000, p. 100) provide a succinct view of safety climate as the “individual perceptions of the value of safety in the work environment”. Kines et al. (2011, p. 638) also put forward their definition of safety climate as “a social unit’s shared perceptions at a given time of management and workgroup safety policies, procedures and practices”.

A key antecedent of the core meaning of safety climate emphasises the “shared” perceptions formed by employees. This antecedent, “symbolic interactionism” (Blumer 1986; Stryker 2008), is the view that the meaning of things and the elucidation of circumstances emerge from the cross-pollination between the individual’s cognitions and those of others of the same status in an organisation (Zohar 2010). Put differently, the commonality among employees’ cognitive constructions of reality due to social interactions produces a consensual and convergent view of how the organisation supports and rewards safety. As such, safety climate perceptions stem from socially construed, shared symbolisms and negotiated agreements (Zohar & Luria 2004). Additionally, there is a growing consensus about the definition of safety climate since most definitions include the term “shared” and “perceptions” (Pousette, Larsson & Törner 2008; Seo et al. 2004). This study therefore follows this universality of thought (e.g. Khoshnava et al. 2020; Lingard, Pirzadeh & Oswald 2019; Lingard, Cooke & Blismas 2009, 2010b; Zohar 1980, 2000, 2010; Zohar & Luria 2004), and, as will be discussed further in the literature, this definition is consistent with the level of analysis considering the theoretical and methodological foundations in this research. In doing so, first, the relevance of safety climate is discussed in the next section.

2.3.1 Why safety climate is important

In the last three decades, numerous studies have focussed on theorising, defining, measuring, and operationalising safety climate, as well as its ability to influence safety outcomes or other safety-related paradigms in the construction industry (e.g. Boateng, Davis & Pillay 2020; Dedobbeleer & Béland 1991; Glendon & Litherland 2001; Lingard, Blismas & Wakefield 2005; Lingard, Pirzadeh & Oswald 2019; Loosemore et al. 2019a; Mohamed 2002; Newaz et al. 2019a, 2019b; Newaz et al. 2018; Sunindijo & Zou 2011; Zhang, Lingard & Nevin 2015). Much of this research has further validated safety climate as a robust leading indicator (Hecker & Goldenhar 2014; Newaz et al. 2019c; Zhou, Goh & Li 2015; Zohar 2010) and predictor of objective and subjective safety measures across industries and economies (Christian et al. 2009; Nahrgang, Morgeson & Hofmann 2011; Patel & Jha 2016; Zou & Sunindijo 2013). For example, researchers in the Swedish construction industry observed that safety climate substantially predicts self-rated safety behaviour seven months ahead (Pousette, Larsson & Törner 2008), before injuries or fatalities occur (Seo et al. 2004).

A fundamental reason for the contemporary focus on safety climate is the need for further improvements in OHS management by drawing insights from the organisational and psychosocial perspectives offered by safety climate investigations (Huang, Chen & Grosch 2010). In other words, safety climate evaluations offer comprehensive evidence concerning antecedents of safety issues and are a valuable analytic instrument (Baker et al. 2020; Meliá et al. 2008; Newaz et al. 2018; Zhang, Lingard & Nevin 2015). In fact, "the concept of safety climate is important insofar as it predicts safety performance within organisations" (Andersen et al. 2018, p. 23). According to Andersen et al. (2018), safety climate is associated with lower rates of self-reported accident. The practical and theoretical strength of the safety climate concept therefore dwells in its skill to forecast safety performance across industries and cultures (Arizon Peretz et al. 2021; Huang, Chen & Grosch 2010; Pousette, Larsson & Törner 2008). A higher safety climate score suggests a stronger future safety performance (Hallowell, Bhandari & Alruqi 2019; Huang, Chen & Grosch 2010; Lingard, Cooke & Blismas 2011, 2012; Zhang, Lingard & Nevin 2015).

According to WorkCover Queensland (2019), a successful safety climate is associated with substantial benefits such as growth in production, improved worker safety knowledge, tendency to behave safely, cuts in worker incident numbers, and increased implementation of safety-related policies and programs. This implies that, shared positive safety climates are related to increased degrees of construction OHS (Arcury et al. 2012; Lingard, Pirzadeh & Oswald 2019; Pousette, Larsson & Törner 2008). Owing to the expected benefits of a positive safety climate, there have been substantial studies into the development of safety climate dimensions and assessment tools (Loosemore et al. 2019a). Acknowledging the consensual and shared nature of climate perceptions, the next section attempts to answer the question, "at what level in the organisation are these perceptions shared?

2.3.2 Levels of safety climate analysis: A conceptualisation

During the "feeling the elephant era" of safety climate conceptualisation, i.e. 1971-1985, a research issue arose. The concern was, "if climate is an attribute of the setting but it is perceived by the individuals in the setting, how can research at the setting level of analysis be conducted?" (Schneider et al. 2017, pp. 470-1). Put simply, the confusion was about "whether climate is an individual experience construct and/or a unit/organisational attribute" (Schneider, Ehrhart & Macey 2013, p. 363). As a means of offering a conceptual representation, James & Jones (1974) provided a label for the individual level of climate studies, which they termed as "psychological climate". This clarification was vital, as it gave scholars in the climate field a collective vocabulary with which to describe the level at which particular research was conducted (Schneider et al. 2017).

Consequently, the introduction of the multilevel paradigm in organisational behaviour studies led to a corresponding modification in the conceptualisation of safety climate (Kozlowski & Klein 2000). Relevant to this discussion, empirical research and theoretical reasoning prove that employees' cognitions of safety climate can be shaped at varying levels and that these cognitions differ substantially between organisational subunits (Lingard, Blismas & Wakefield 2005; Lingard, Cooke & Blismas 2009; Lingard, Cooke & Blismas 2010a; Zohar 2000, 2008, 2010; Zohar & Luria 2005). Thus, the distinction provided more clarity in terms of defining, measuring, and differentiating climate priorities at appropriate organisational hierarchies. In effect, safety climate has been respecified as a multilevel construct (Meliá et al. 2008; Zohar 2000, 2010; Zohar & Luria 2005).

Safety climate has been analysed at the individual, group, and organisational levels (Boateng, Davis & Pillay 2020). James & Jones (1974, p. 1110) referred to psychological climate as "individual attributes, namely the intervening psychological process whereby the individual translates the interaction between perceived organisational attributes and individual characteristics into a set of expectancies, attitudes, behaviours, etc…". The psychological climate consists of an individual's cognitions about a rational set of policies, procedures, and practices (Ostroff, Kinicki & Tamkins 2003). Drawn from psychological climate, the individual safety climate is also termed a psychological safety climate. Likewise, psychological safety climate refers to the individual's perceptions of the value of safety in the workplace (Christian et al. 2009; Neal & Griffin 2006). When these perceptions are shared by individuals within a group or organisation, they are termed “group climate” or “organisational climate” (Neal & Griffin 2002).

Group climate denotes supervisory and group practices, while organisational climate suggests senior management’s policies and procedures, and the priorities they support (Andersen et al. 2018; Zohar 2000, 2008). Zohar conceptualises safety climate at both group and organisation levels (Shen, Zhang, et al. 2017). At the group-level, safety climate describes the cognitions employees form about how the supervisors translate management policies and procedures into regular practice (Brondino, Silva & Pasini 2012). Put differently, the group safety climate refers to shared perceptions of the workplace features as they relate to safety issues that influence a set of employees (Christian et al. 2009; Zohar & Luria 2005). To summarise, safety climate is inherently a multilevel construct (Zohar 2011). In doing so, the next section argues for the need to focus on the group and organisational level of safety climate considering the physical and socially proximal nature of construction activities and personnel.

2.3.3 The case for group and organisational-level safety climates

Zohar (1980, p. 96) defined safety climate as “a summary of molar perceptions that employees share about their work environments”. This original definition of safety climate theorises that “the concept of safety climate implies that production workers indeed have a unified set of cognitions regarding the safety aspects of their organisation” (Zohar 1980, p. 101). These insights highlight key concepts in safety climate as unified, consensual, shared, or agreed upon (Hofmann, Burke & Zohar 2017; Kath, Magley & Marmet 2010; Lingard, Pirzadeh & Oswald 2019; Pousette, Larsson & Törner 2008; Schwatka & Rosecrance 2016; Zohar 2008, 2011, 2014). Distinct from the psychological safety climate, the group and organisational safety climates permit the aggregation of employees' perceptions. This aggregation of cognitions emerges from the perceptual assessments and social constructions of individuals (Ostroff, Kinicki & Muhammad 2013). Zohar (2000) postulates that, at the group-level of safety climate, perceptions converge to become practices-as-patterns instead of secluded activities. Employees focus on established procedures because, when viewed as a pattern, they offer information about desired role behaviour even when no specific procedures are available (Reason 1990). For workers' perspectives to be mutual, an impartial certainty in the peripheral setting must be noticeable and adequately prominent so that workers can concur in their views (Neal & Griffin 2006). Climate perceptions, therefore, must be engaged in the cooperative quest for cues, and afterwards in testing and validation, resulting in a socially construed consensus that makes an atmosphere more comprehensible (Zohar & Luria 2005). In summary, consensus means perceptions are shared (Schneider, Ehrhart & Macey 2013).

Zohar (2000) adds that these shared perceptions or established agreements should signify the comparative priorities of safety, and not the content of individual procedures. Importantly, the distinctiveness of climate as a trait of the group or organisation was a key step for climate studies, although some scholars still investigate climate at the individual level (Schneider, Ehrhart & Macey 2013). As such, the multilevel model of climate, as put forward by Zohar (2000, 2008); Zohar & Luria (2005), specifies that climate arises from consensual motive-relevant appraisals of important aspects of the organisational setting. Unlike industries such as transportation (e.g. lone workers such as long-haul truck drivers), where psychological safety climate plays a greater role (cf. Zohar et al. 2014), the nature of other industries, such as manufacturing, construction, and health-care, includes daily possibilities for social interaction with co-workers, supervisors and top management (Lingard, Cooke & Blismas 2010a; Zohar et al. 2014). Hence, by default, symbolic social interaction, which is an antecedent of organisational climate, thrives within the organisational and group safety climates of the construction industry, where workers are in physical and social proximity, whereas psychological safety climate, e.g. in lone working industries, do not involve social symbolic relations (Zohar et al. 2014). In effect, recent meta-analytic evidence by Beus et al. (2019) demonstrated that group-level safety climate relationships with historical safety incidents are almost two times stronger than at the individual level. Moreover, there are different individual views at the psychological climate level, denoting insufficient consensus with organisational reality (Zohar & Tenne-Gazit 2008). Because the nature of measuring psychological safety climate from an individual's perspective is diluted by the distinctive nuances of a person (Christian et al. 2009). Group safety climate is thus a stronger predictor of safety performance than psychological safety climate (Neal & Griffin 2006). Of central importance to this discussion, the lack of shared perceptions connotes the absence of group and organisational climates (James et al. 2008).

In spite of these debates, a large volume of empirical studies has examined the influence that psychological safety climate has on safety outcomes/performance at the individual level (Clarke 2006b; Shen et al. 2015). Often forgotten, the aggregation of individual-level climate to form organisational climate had earlier been cautioned against by James & Jones (1974), except when the truth of perceptions is verified by establishing their correlations with "objective measures" (James & Jones 1974; Schneider et al. 2017). The choice to aggregate individual climate perceptions is mostly made on the grounds of two conditions: (1) theoretical validation for regarding climate as a group-level construct; and (2) numerical validation established on commonality statistics validating aggregation of individual climate cognitions (Bliese 2000; Kozlowski & Klein 2000; Zohar et al. 2014). On the other hand, a majority of safety climate studies have focused on the organisation level of analysis (Andersen et al. 2018; Cooke, Lingard & Blismas 2013;

Lingard, Cooke & Blismas 2011; Lingard, Cooke & Blismas 2009; Lingard, Cooke & Blismas 2010c; Newaz et al. 2018). Such studies implicitly presume that employees in construction organisations share an identical view of the value put on OHS (Lingard, Cooke & Blismas 2009). However, considering that employees' cognition of safety climate can be shaped at different levels (Zohar 2010; Zohar & Luria 2005), it remains more suitable to embrace a multilevel safety climate model in construction (Lingard, Cooke & Blismas 2009).

Accordingly, it is not sufficient to focus on the organisation as the only unit of analysis (Cooke, Lingard & Blismas 2013). As a result, there is a need for studies at the group level (cf. Cooke, Lingard & Blismas 2013; Liang, Zhang & Su 2020), because group safety climates have a higher propensity to emerge in decentralised organisations, such as in construction (Lingard, Cooke & Blismas 2009; Newaz et al. 2018), where the majority of workers have infrequent interaction with senior management and are more likely to be impacted more frequently by their relationships with colleagues in their close groups (Andersen et al. 2018). The workgroup is therefore the most proximal and prominent social unit in the organisation (Ashforth 1985; Clarke 2006a). As such, it is expedient to consider safety climate at the group-level (Beus et al. 2019). Importantly, it remains necessary to adopt safety climate at the group and organisational levels (Andersen et al. 2018; Hofmann, Burke & Zohar 2017). In line with this reasoning, as well as with the core meaning of safety climate, and the recommendations by climate commentators/pioneers, the premise of this research follows Zohar (2000, 2008), 2011); Zohar & Luria (2005) operationalisation of the multilevel model of safety climate analysis, thus employing group and organisational-level assessments. In what follows, the group level of safety climate is further expanded to integrate co-workers as having considerable influence on how other co-workers perceive the value of safety.

2.3.4 Co-workers as important agents of change in a group safety climate

The utmost goal of safety climate perceptions is the actual importance of safety, in that the perceptual degree echoes its harmoniously measured importance by organisational workers (Zohar 2008). In this respect, the group-level of safety climate analysis has been extended to embrace co-workers (Brondino, Silva & Pasini 2012; Lingard, Cooke & Blismas 2011; Meliá et al. 2008; Zohar 2010) beyond the role and influence of supervisors in such climate levels (Newaz et al. 2019a; Newaz et al. 2021; Zohar 2008; Zohar & Luria 2005). This implies that workers belonging to an organisation, and its subunits, will cultivate synchronous and consensual climate perceptions (Zohar 2008). As such, convincing evidence from psychology stresses the necessity to study the effect of co-workers in a group safety climate (e.g. Ashforth 1985; Bandura 1986). According to Schneider (1987), co-workers are not just a crucial component of the social setting at the workplace, they actually define it. Co-workers can therefore support and antagonise their fellows (Chiaburu & Harrison 2008; Thibaut 2017). Given this, co-workers have been considered an essential component of the multilevel model of safety climate (Brondino, Silva & Pasini 2012).

Despite the relevance of co-worker influence, research at the group level of safety climate is inclined to forget the function of co-workers and direct much effort to workers' perceptions of supervisory leadership to denote the group safety climate (Brondino, Silva & Pasini 2012; Lingard, Cooke & Blismas 2009). The lack of focus on the social and team practices that are integral to construction sites has led to challenges for attempts to minimise accident rates (Koh & Rowlinson 2012; Love, Goh & Smallwood 2012). Strong empirical evidence from a more recent study by Lingard, Pirzadeh & Oswald (2019) that considers the formation of safety climate perceptions from a social network perspective reveals co-worker-to-co-worker communication strongly contributes to the creation of group safety climates, far more than the influence of worker-to-supervisor and supervisor-to-worker communication. This suggests that many more studies are required to go beyond the leadership-worker relationship (e.g. Newaz et al. 2019a), in order, to augment safety climate theory (Zohar 2010). Brondino, Silva & Pasini (2012) also found that co-worker safety climate had a stronger impact on safety behaviour than the supervisor's safety climate at both individual and group levels, on the basis that individuals without official authority can significantly impact group norms and organisational climates (Lingard, Cooke & Blismas 2011). Thus, construction workers who mostly work in teams view their colleagues as work task "experts", rather than their site managers (Andersen et al. 2018; Lingard, Cooke & Blismas 2011). Notably, co-workers provide information and interact in conduct validation for some activities while deterring others, helping to mould a fellow's dogmas about the "do's and don'ts" (Chiaburu & Harrison 2008; Ilgen & Hollenbeck 1991). Hence, as Lingard, Cooke & Blismas (2010a, p. 1101) argue, considering the "supervisory environment and co-worker facets of safety climate, the workgroup is a more appropriate unit of analysis".

In summary, though leadership stimulates collective cognition by providing explanatory consensus and activity validity, social interaction within a crew offers a greater influence (Zohar & Tenne-Gazit 2008). The role of co-workers in a group safety climate has therefore been the focus of construction scholars (e.g. Andersen et al. 2018; Lingard, Cooke & Blismas 2011; Lingard, Pirzadeh & Oswald 2019; Meliá et al. 2008), albeit the empirical research linked to this area is quite limited (cf. Jiang et al. 2010; Lingard, Cooke & Blismas 2011; Schwatka & Rosecrance 2016). Similarly, safety climate studies have seldom used items about co-workers (Brondino, Silva & Pasini 2012). Thus, only a few prior empirical studies have explored how workers perceive their co-workers' commitment to safety (Burt, Sepie & McFadden 2008; Schwatka & Rosecrance 2016), and co-workers causal influences are not well comprehended in construction (Schwatka & Rosecrance 2016). Recognising the important contribution of co-worker influence, this growing body of literature can have a substantial influence on OHS performance (Jiang et al. 2010). To provide a thorough analysis of well-aligned and shared views of safety climate, the thesis of this research includes the worker's perception of their co-workers' safety values and priorities, along with that of supervisors at the group level of measurement. Given this, the next section discusses the techniques in measuring these shared perceptions.

2.3.5 Measurement of safety climate: An appraisal of approaches

Typically, the intent for assessing safety climate is to offer prospects for investigation or modification (Carroll 1998; Morrow et al. 2010), in order to advance safety performance in the investigated institution (Cooper & Phillips 2004; Huang, Chen & Grosch 2010; Probst et al. 2019). A favourable safety climate therefore provides workers with cues and subsequently validation on the role behaviour that is accepted, prioritised, and rewarded in the organisation (Kines et al. 2011; Zohar & Luria 2004). As such, an accurate measure of safety climate depicting employees' socially construed views of workplace safety is paramount in evaluating the true climate level and strength of that organisation. A consistent and effective assessment of safety climate, as well as increasing the predictive power of its scales, is essential (Jiang, Lavaysse & Probst 2019). It is therefore relevant to question, how this study intends to accurately measure safety climate. To answer this, the onus is on this section to pin down the appropriate mediums and approaches required to paint an actual portrait of safety climate in this research project.

Two common aggregation methods have been used with safety climate assessments, namely, direct consensus and referent-shift consensus (cf. Probst et al.

2019; van Mierlo, Vermunt & Rutte 2009; Wallace et al. 2016). The reference-shift approach treats an employee as a rapporteur of shared perceptions (Kines et al. 2011). This composition model encourages employees to report on cognitions agreed upon in the organisation as well as its subunits. The approach shifts the referent from the self to the collective prior to consensus evaluation (Chan 1998; Glisson & James 2002; van Mierlo, Vermunt & Rutte 2009), for example, wording questionnaire items, such as "I believe my co-workers can…", "in our work environment, safety is…", "my co-workers", "everyone aims…", and "in my group, we adopt…", in a shared perceptual manner, rather than "I believe I can…". These peer ratings have also been referred to as "non-self-report measures" (Chan 2009). With the referent-shift approach, shared perceptions concern circumstances in high-level structures, such as the group or organisation. Contrariwise, the direct consensus approach tends to use questionnaire items such as "I aim" and "I believe I can". When compared to the direct consensus method, Chan (2009) explains that self-report data denotes data acquired through surveys comprising items that probed participants to report something about themselves. Simply put, with direct consensus, items refer to the individual, whereas the referent-shift consensus has its items referring to the group (James et al. 2008; van Mierlo, Vermunt & Rutte 2009). When using the direct consensus approach individual perceptions operationalised at a lower level are expected to be functionally isomorphic to a higher level (cf. Chan 1998).

The use of self-report data or a direct-consensus approach could result in common method variance (Andersen et al. 2018; Morrow et al. 2010; Neal, Griffin & Hart 2000) and construct validity issues. Several limitations associated with self-reports have also been expressed by numerous safety climate researchers (e.g. Andersen et al. 2018; Fogarty & Shaw 2010; Gao, González & Yiu 2020; Kapp 2012; Mearns et al. 2010; Morrow et al. 2010; Newaz et al. 2019c). These phenomena may limit the analytical accuracy of employees' representations of complexity in their perceived reality, hence, disrupting the means to implement "tailor-made" interventions to improve workplace safety. Considering these flaws, studies using self-report data have often faced consistent methodological criticisms from journal editors and reviewers during the review process (Chan 2009). This may have led to authors acknowledging these flaws as a drawback in most self-report empirical research. Other sources of data, such as co-worker' reports, have been recommended (Morrow et al. 2010) to lessen artificial inflation of correlations associated with self-reports or the direct-consensus approach (Kines et al. 2011; Mearns et al. 2010). Pertinent to this discussion, recent meta-analytic evidence by Wallace et al. (2016) demonstrates that the referent-shift consensus would be more beneficial to practitioners when examining performance-related outcomes for groups, teams, or other units of interest in association with climate variables. Moreover, the use of self-report measures is often necessary when constructs used in the assessment are self-perceptual (Chan 2009). In contrast to self-reporting, the concept of safety climate (as discussed in previous sections) has been theorised as being characterised by "shared", "consensual" perceptions and among others suggests a more inherently "group-experiential" nature.

The cogency given to safety climate concepts and word constructions has a favourable propensity to produce acceptable high intra-correlations (Kines et al. 2011). Put simply, a robust safety climate scale can satisfactorily capture the consensual views among employees in the organisation and its subunits. This suggests that rewording items to make the shift in referent obvious imparts greater within-group consistency (Klein et al. 2001). In effect, items with group referents can capture group-level constructs (Klein et al. 2001). Despite these benefits, numerous studies mostly overlook the use of the referent-shift approach in the development of safety climate instruments (Kines et al. 2011). Recent studies in the assessment of safety climate have mostly used self-report questionnaires (Newaz et al. 2018). With these justifications, the referent-shift aggregation strategy is well-aligned with the multilevel model of analysis adopted in this research project and hence is selected to reflect respondents/workers shared views.

A key issue in the mensuration of safety climate has been whether to use industry-specific or universal measures (Zohar 2014). The universal measures depend on developing generic scale items that reflect context-free views of safety climate, whereas industry-specific measures are rooted within a specific industrial sector echoing the unique peculiarities in that industry (Jiang, Lavaysse & Probst 2019). Examples of universal safety climate measures include those developed by Beus et al. (2019); Kines et al. (2011); Zohar (1980). On the other hand, examples of industry-specific questionnaires have been developed/adapted for the construction industry by Dedobbeleer & Béland (1991); Hon, Chan & Yam (2013); Li et al. (2017); Mohamed (2002); Newaz et al. (2019c); Wu et al. (2015); Zahoor et al. (2017); Zhang, Lingard & Nevin (2015). While both measuring scales have their benefits, an important question lies in the predictive power surrounding these measures (Jiang, Lavaysse & Probst 2019; Zohar 2014). This prompts the question: which measure has superior predictive power?

Contemporary meta-analytic evidence shows that industry-specific measures tend to provide a better prediction of definite safety-related consequences such as safety behaviour and risk perceptions than universal safety climate measures, whereas, universal safety climate tools demonstrated superior predictive abilities when estimating fatal mishaps (but not accidents and injuries) (Jiang, Lavaysse & Probst 2019). Further studies such as Huang et al. (2012) within the trucking industry corroborate the superior predictive power of industry-specific safety climate measures over universal measures when effect sizes of trucking-specific items were double that of generic items (Zohar 2014). The generic nature of universal measures is therefore not beneficial for the prediction of specific outcomes (Schneider, Ehrhart & Macey 2013). This research project employs industry-specific measures that consider the overarching predictive power of an industry-specific safety climate strategy and the outcome variables (safety behaviour, accidents, injuries, and near misses; as will be delineated in Section 2.4 to 2.4.3) used in this study. To this end, the use of industry-specific scales can tease out fundamental formations through which consensual views develop (Zohar 2010). However, at which levels of climate formation do the safety climate dimensions within the industry-specific measure operate? The following section attempts to answer this query.

2.3.6 Facets of group and organisational safety climates

Several safety climate studies still suggest ideal climate factors; nevertheless, this has encouraged the prevalence of dimensional inconsistencies and debate surrounding the concept of safety climate (Boateng, Davis & Pillay 2020). These disparities stem from the fact that safety climate scholars have substantial liberty to label dimensions, and there is less agreement among them (Guldenmund 2000; Jones & James 1979). These inconsistencies induce misperceptions and problems for scholars and professionals when assessing safety climate (Wu et al. 2015). Guldenmund (2000) earlier suggested, as an antidote to this chaos, that; the frequency at which certain dimensions are studied could be a sign of ubiquitousness or relevance. Following this recommendation, there seems to be a certain level of convergence on some safety climate dimensions postulating a favourable state of homogeneity. The majority of safety climate research tends to focus on measurement issues (Loosemore et al. 2019a; Zohar 2010); however, there is the need to advance safety climate studies from a recurring attention on measurement to an increased focus on more essential matters (Beus et al. 2019; Zohar 2008), for the reason that, “merely developing more measurement scales…will hold back scientific progress” (Zohar 2008, p. 385). Hence, using comprehensive systematic literature reviews and meta-analytic evidence, dimensions denoting high agreeableness are used to yield some insight into which industry-specific measure to adapt in this study, rather than developing another safety climate instrument.

A recent systematic review by Newaz et al. (2018) in the construction industry identified the eight most common safety climate dimensions from 16 studies, i.e. “management commitment”, “safety management, rules, practices and procedures”, “supervisor’s role”, “workers’ involvement”, “group safety climate”, “communication and relationships”, “safety training”, and “work pressure”. Following a review of 107 construction studies, Alruqi, Hallowell & Techera (2018) also identified fourteen common safety climate dimensions, and presented the top eight as “management commitment to safety”, “supervisory safety response”, “safety rules and procedures”, “communication”, “worker involvement”, “training”, and “risk-taking behaviour”, “workload pressure”. Schwatka, Hecker & Goldenhar (2016) also identified the eight most measured dimensions in 56 construction-specific safety climate studies. These were “general management commitment to safety”, “safety policies, resources, and training”, “supervisor commitment to safety”, “general organisational commitment to safety”, “co-workers commitment to safety”, “safety communication”, “worker involvement in safety”, and “risk appraisal and risk taking”. These consensually agreed-upon facets, suggesting a satisfactory level of convergence are used as a heuristic for selecting the industry-specific safety climate instrument for this study.

While a substantial amount of research has emphasised safety climate in the industry, these scientific enquiries lack detail about climate dimensions and investigation level (Alruqi, Hallowell & Techera 2018). Among a few, a sample industry-specific tool that seems to have most, if not all, of its facets listed among the common dimensions is that of Mohamed (2002). Mohamed's ten dimensions include “commitment”, “communication”, “safety rules and procedures”, “supportive environment”, “supervisory environment”, “workers' involvement”, “personal appreciation of risk”, “appraisal of work hazards”, “work pressure”, and “competence”. Alruqi, Hallowell & Techera (2018) identified six climate tools that have been modified and used in the construction industry, of which Mohamed (2002) safety climate tool has been tested among Australian construction workers. Considering that, existing safety climate items require cultural modifications to a particular country and region (Zahoor et al. 2017), this study adapts (using referent-shift consensus) Mohamed (2002) survey instrument, as it is appropriate for the same Australian context.

However, a key question concerns the operationalisation of the dimensions at specific climate levels. In other words, at which climate level does each of the dimensions function? As discussed in previous sections, this study employs a multilevel model in line with Zohar (2000) two levels of safety climate analysis, i.e. group and organisational safety climates. Group safety climate perceptions emerge from the safety practices related to the enactment of organisation policies and procedures within workgroups (Zohar 2000). Sources of climate views at the group level relate to the practices of co-workers, and policies and procedures implemented by supervisors (Lingard, Cooke & Blismas 2011; Meliá et al. 2008; Zohar & Luria 2005), whereas those at the organisational level arise from formal organisational policies and procedures laid down by top management (Zohar 2000). A fundamental criterion for determining which dimension operates at which level draws from Schneider, Ehrhart & Macey (2013) proposition.

According to Schneider, Ehrhart & Macey (2013), wording climate survey items in a manner such that they mirror the analysis level at which data will be aggregated could provide consensual and reliable evidence. In line with this recommendation, separate measures should be developed based on the objective of climate views, as it can link to either the organisation or group levels (i.e. top management commitments and policies versus supervisory or co-worker practices) (Zohar 2010). Notably, these distinctions are relevant in order to avoid levels of discrepancy between theory and measurement units (Zohar 2000, 2010). For instance, a dimension such as management commitment has an item sample such as "management considers safety to be equally as important as production". This wording explicitly refers to management, which has been known to be an aspect of organisational safety climate (cf. Lingard, Cooke & Blismas 2010a). The same is true for a referent of the "communication" dimension with an item sample such as "management operates an open-door policy on safety issues".

On the other hand, bearing in mind that a core distinction of the organisational climate dwells in the enactment of policies and procedures by top management (cf. Zohar & Luria 2005), the dimension "current safety rules and procedures" with a sample item such as "current safety rules and procedures are made available to protect my co-workers from accidents" is thus at a higher level, i.e. organisational. From the foregoing, three out of the ten dimensions from Mohamed (2002) survey tool are relevant at the organisational level, whereas the remaining seven function at the group level, as they all are in reference to everyone, group, co-workers or supervisor, except the dimension “appraisal of physical work environment and work hazards”, which has a shift in referent to the work environment.

Considering the dimension “appraisal of physical work environment and work hazards”, an item example, “in our work environment, safety is a primary consideration when determining site layout”, which neither explicitly specifies the co-worker, supervisor, nor management, is yet still proximal to employees’ perceptions at the workgroup level, for the reason that dimensions that exploit the larger work environment may be more robust for variances between self-reference versus collective reference (Kozlowski & Klein 2000). This level of robustness in consistency denotes features of the group level suggestive of a lower within-group variance since workers naturally interact more often with their work environment. Considering such close proximity, individuals can serve as expert informants for higher-level constructs, as they can observe or have exclusive knowledge of the work environment (Duryan et al. 2020; Kozlowski & Klein 2000). This dimension further resonates with the definition of group-level safety climate as consensual cognitions of work environment features as they relate to safety issues that influence the workgroup (Christian et al. 2009; Zohar & Luria 2005). As such, the degree to which the work environment is useful or hazardous to the group is theoretically a group-level facet (cf. Christian et al. 2009; James et al. 2008). In brief, the relative frequency of interactions implying either a proximal or distal dimension of employees’ perceptions concerning the priority of safety is a clear distinguishing factor of the level at which a dimension operates.

From the preceding sections, the discussions show that due to the complexity of the construction industry, the role co-workers play in impacting attitudes, behaviour and performance is crucial (Chiaburu & Harrison 2008; Fugas, Meliá & Silva 2011). A recent study by Lingard, Pirzadeh & Oswald (2019, p. 6) revealed that "neither supervisor in-centrality nor supervisor out-centrality was significantly related to the workgroup safety climate…nor were they significant predictors of safety climate…". This finding echoes the relatively strong contribution of co-workers communication to the formation of group safety climates, far more than that of supervisors (Lingard, Pirzadeh & Oswald 2019). According to Burt, Sepie & McFadden (2008); He et al. (2020), co-worker safety should be treated as a separate factor to the group safety climate. As such, a more specific assessment may be required to evaluate these two unique agents (i.e. co-workers and supervisor) of the group safety climate system in isolation (cf. Andersen et al. 2018). This study thus follows the proposition of differentiating between member-to-member symbolic interactions and leader-member interaction (cf. Zohar & Tenne-Gazit 2008). Figure 2.1 shows the facets of the group and organisational climates as theorised. It distils discussions in this and earlier sections on safety climate. Constructs transition from the right to left indicating the reflective-formative model type. In a reflective-formative model, the lower order construct indicators (e.g. SuppEnv_6: In my group, we maintain good working relationships) are reflective and the lower order construct (e.g. supportive environment) to the higher order construct (e.g. workgroup safety climate) is formative (Matthews, Hair & Matthews 2018). Therefore, the arrows indicate formation of the constructs rather than a direction of influence. To this end, after theorising and establishing safety climate within the context of this study, the next section introduces safety behaviour, the key construct influenced by safety climate.

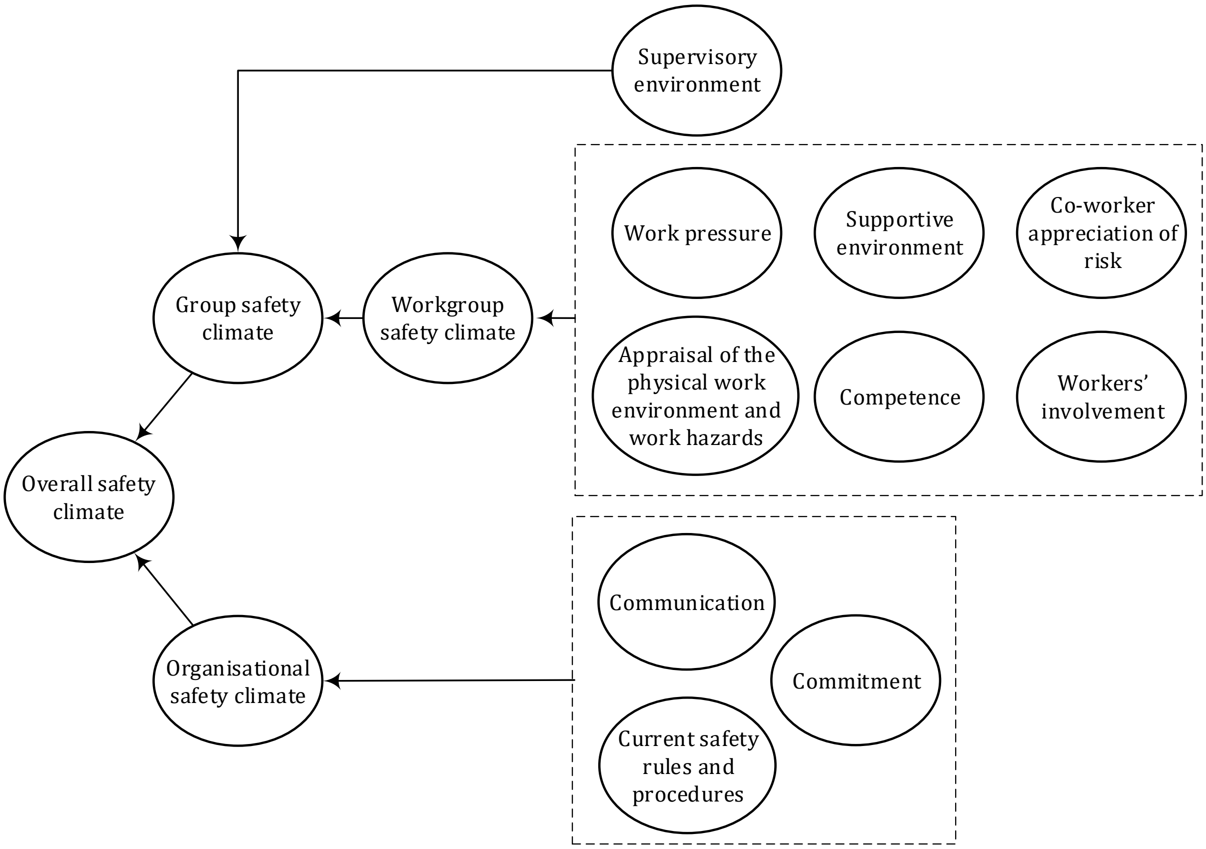

Figure 2. 1: Facets of the group and organisational safety climates.

2.4 Safety Behaviour: An Overview

Safety behaviour refers to the individual behaviour that encourages OHS of their self and workplace (Burke et al. 2002), while unsafe behaviour denotes any behaviour exhibited by a worker without bearing in mind safety rules, principles, processes, guidelines, and particular benchmarks in the organisation (Mearns et al. 2001). Attention to the role that human behaviour plays in OHS developed in the 1930s when accident reports showed that 95% of workplace accidents were due to unsafe worker actions (Cooper & Phillips 2004; Geller 2016). This focus on safety behaviour has continued to grow in recent years (Scott, Fleming & Kelloway 2014), as unsafe behaviour is an ongoing managerial challenge (Zohar & Luria 2003).

Statistics show that not less than 80% of fatal incidents may be associated with the acts and neglect of people (Health and Safety Executive 2009). Other safety experts, such as Lingard & Rowlinson (2004), put this percentage even higher, positing that a range of 80-90% of all fatal incidents are fuelled by the inappropriate behaviour of employees. To be more specific, Suraji, Duff & Peckitt (2001) and Sunindijo, Zou & Dainty (2017) place these figures at 88% and 90%, respectively. Unsafe behaviour by workers at the workplace can cause accidents, fatalities, or injuries, as well as incur significant costs and loss of corporate reputation (Sing et al. 2014). To the construction organisation, these costs constitute overtime premiums, employer access payments, sick leave, staff turnover costs, threshold medical payments, legal costs incurred plus fines and penalties, and/or employer investigation costs. Specifically, unsafe behaviour is acknowledged as a huge predictor of workplace accidents (Panuwatwanich, Al-Haadir & Stewart 2017).

According to Love, Goh & Smallwood (2012, p. 99), "more research is required to better understand why accidents should not occur!" This call for further research begs the question, why should unsafe behaviour by construction workers not occur? It is therefore essential to gain insights into what causes employees to work unsafely, to intentionally violate safety rules and practices, and engage in largely inappropriate behaviour (Scott, Fleming & Kelloway 2014). Behavioural biases could provide the required anaesthesia needed to dissect why workers underweight outcomes (Zohar 2002b; Zohar & Erev 2007). Examples of such biases include melioration bias (Herrnstein 1961, 1979; Herrnstein et al. 1993) (Melioration is defined as "choosing a lesser gain over a greater longer term gain" (Sims et al. 2013, p. 139)), rare-events (Erev 2007; Plous 1993), and social externalities (Akerlof 1997; Zohar & Erev 2007). According to Zohar & Luria (2003), melioration bias pertains to the propensity to ascribe greater weight to short-term outcomes when deliberating on action choices (such as whether to prioritise safety, quality, or productivity), whereas recency bias refers to the propensity to under-value, or be oblivious to, the weighed likelihood of being unfavourably affected by rare negative events. This bias leading to underweighting of rare events, and seems to originate with amassing of experience (Cohen & Erev 2018). On the other hand, social externalities are outcomes that impact others as an effect of the decision of the decision-maker (Zohar & Erev 2007). Together, these cognitive biases lead to the inclination to favour unsafe behaviour.

In construction site circumstances, safe behaviour leads to non-events (avoidance of low-probability injury), whereas unsafe behaviour appears to lead to perceived support and tangible benefits (such as comfort, increased speed, and minimal/reduced effort) (Zohar & Luria 2003). According to Love et al. (2017), there is a high proclivity for workers to engage in unsafe acts since they may be faced with having a compromise between the available information and time or violate the rules to make work more efficient. As a result, the perceived evaluated benefits of unsafe behaviour will mostly dwarf those of safe behaviour (Barron & Erev 2003a). In line with these premises, it is evident that neglecting to wear available personal protective equipment (PPE) contributes to about 40% of occupational accidents and diseases, and this rate has not changed for more than two decades, despite continual endeavours to address the situation (National Safety Council 2003; Zohar 2002b; Zohar & Erev 2007; Zohar & Luria 2003).

In Australia, cases such as the construction of the Forrestfield Airport Link in Perth revealed that “it is only when an adverse event results in a severe injury or death that an evaluation is undertaken to assess whether improvements can be made to reduce the likelihood of similar events occurring in the future” (Love et al. 2020, p. 2). In other instances, such as among Dutch railway workers, Elling (1991) found that “95% thought that, if you kept to the rules, the work could never be completed in time” (Hale & Borys

2013). To minimise or break this cycle of inappropriate behaviour and safety violations, Zohar & Erev (2007); Zohar & Luria (2003) suggest the institution of interventions that adjust the value utility for safe behaviour by ushering in short-term rewards that offset immediate costs. Noteworthy, safety behaviour is often confused with safety outcomes and performance, hence, a theoretical demarcation is provided between these concepts in the following section to avoid ambiguity.

2.4.1 Safety performance: Distinguishing behaviour and outcomes

The theory of job performance assumes that job performance is behavioural, periodic, evaluative, and multidimensional (Motowildo, Borman & Schmit 1997). In other words, job performance is a property of behaviour or a result of different behaviours occurring at various times. The evaluative nature of performance signifies the value of these behaviours, whether negative or positive, which could affect the organisational goal (Motowidlo 2003). As would be discussed further, the dimensional nature of job performance refers to a part of performance focussing on formal job descriptions, and the other emphasising the quality of personal skills/knowledge, interpersonal interactions (e.g. interpersonal trust) among individuals and use of organisational resources (Motowidlo & Kell 2012). Job performance is defined as the accumulated value to the organisation of the distinct behavioural episodes that an individual completes over a standard interval of time (Motowildo, Borman & Schmit 1997). Traditionally, job performance is the extent to which an individual contributes to the realisation of an organisation's goals (Campbell et al. 1993; Ford & Tetrick 2008). Derived from job performance theory, Borman & Motowidlo (1993) distinguished two aspects of job performance, task and contextual performance. Task performance by workers is defined as the activities that are officially established as part of their jobs, activities that contribute to the organisation's technical core either directly or indirectly (Borman & Motowidlo 1993). Whereas contextual performance encourages the organisational, social and psychological environment in which the technical core must operate (Borman & Motowidlo 1993).

However, it is essential to distinguish between behaviour, performance, and outcomes, as they are distinct (Christian et al. 2009). According to Motowildo, Borman & Schmit (1997) behaviour is what people do while at work, and performance is behaviour with an evaluative element. Given this, behaviour is used for measuring performance, and, as a result, safety behaviour is used to evaluate safety performance in construction (e.g., Neal, Griffin & Hart 2000; Newaz et al. 2019b; Shin, Gwak & Lee 2015; Teo, Ling & Ong 2005; Tholen, Pousette & Torner 2013). Outcomes are states or circumstances of people or things that are altered by performance, and consequently either contribute to or detract from organisational goal accomplishment, hence making it appealing to focus on outcomes when considering individual performance (Motowildo, Borman & Schmit 1997). This premise has resulted in two strands of empirical research regarding construction safety performance.

One strand focuses on measuring safety behaviour as performance (e.g., Cooper & Phillips 2004; Neal, Griffin & Hart 2000; Newaz et al. 2019a) and the other strand measures safety outcomes (such as the number of accidents/near misses) as performance (e.g., Ghodrati et al. 2018; Hinze, Devenport & Giang 2006; López Arquillos, Rubio Romero & Gibb 2012; Love, Teo & Morrison 2018; Raviv, Shapira & Fishbain 2017; Wu et al. 2010). The former is often termed "leading indicators", while the latter is referred to as "lagging indicators". Lagging indicators focus on the study of historical accidents statistics to evaluate safety performance (Oswald et al. 2018; Teo & Fang 2006) while leading indicators attempt to capture how well an organisation manages OHS (Lingard, Wakefield & Cashin 2011). According to the latter, safety performance is defined as the "evaluative actions or behaviours that individuals exhibit in almost all jobs to promote the health and safety of worker, clients, the public, and the environment" (Burke et al. 2002, p. 432). Thus, safety performance and safety outcomes as used in this research are distinct (cf. Christian et al. 2009). From these discussions, safety behaviour is used in this study as a measure of safety performance, and the number of accidents/near misses is used to measure safety outcomes. After differentiating safety outcomes from safety behaviour, two types of safety behaviour are explained in the subsequent section.

2.4.2 Aspects of safety behaviour

Based on the Borman & Motowidlo (1993) distinction between task and contextual performance, two aspects of safety behaviour have emerged. Task performance became safety compliance, and contextual performance became safety participation. For example, derived from the definition of task performance such as the core activities that are required to be performed by individuals in the workplace, safety compliance describes how individuals carry out their job when they use the necessary safety equipment (SafCom_1), adhere to safety procedures (SafCom_2), and ensure the highest levels of safety (SafCom_3). On the other hand, based on the definition of contextual performance such as individuals involvement in voluntary activities, safety participation suggests how individuals in their organisation promote safety programs (SafPart_1), put in extra effort to improve safety (SafPart_2), and voluntarily perform tasks that improve workplace safety (SafPart_3). Neal & Griffin (2006) defined safety compliance as the primary undertakings that people are required to perform to sustain safety at the workplace, while safety participation refers to behaviour that does not directly result in an individual's self-safety but does aid in developing a supportive environment for safety (Beus, McCord & Zohar 2016; Neal & Griffin 2006). In terms of characteristics, compliance is compulsory and participation is voluntary (DeArmond et al. 2011).

Mohamed (2002) used two approaches to assess safety behaviour; (1) respondent self-reports safety behaviour, and (2) respondent reports co-workers' behaviour. However, the measure of co-workers is more generalised and reliable than a respondent who self-reports his/her behaviour (Patel & Jha 2016) because "we do not know to what extent people really do what they claim to do" (Pousette, Larsson & Törner 2008, p. 404). With the co-workers' measure of safety behaviour, the bias in reporting is lessened to some degree. This method is quite similar to the norm-elicitation protocol developed by Burks & Krupka (2012) in identifying ethical norms, personal ethical opinions, and related behaviour. The co-workers' measure of safety behaviour is well aligned with the referent-shift aggregation strategy employed at the multilevel model of safety climate analysis in this research project. Similar to the referent-sift consensus approach, the co-workers' measure of safety behaviour technique targets the group level, hence yielding shared perceptions. For instance, with the co-workers' measure of safety behaviour, a respondent can indicate their level of agreement on statements such as "SafCom_1: My co-workers use all the necessary safety equipment to do their job" and "SafPart_1: My co-workers promote safety programs within the organisation".

Based on the reasoning that safe behaviour reduces the prospect of adverse events/near misses, near misses has functioned as a proxy for actual accidents (Glendon & Clarke 2015). A near miss is an event in which no damages or injuries occurred but, under slightly different conditions, could have resulted in harm (Kunreuther, Bier &

Phimister 2004). A near miss provides insights into possible accidents and offers a significant opportunity to further improve safety margins (Heng et al. 2016). Some organisations adopt the near-miss metric as a leading indicator; however, not everyone agrees with this categorisation (Hinze, Thurman & Wehle 2013). According to Toellner (2001), the only distinction between near miss and injury/fatality is luck. Likewise, Griffin & Curcuruto (2016) suggest that a near miss is only a disruption in the sequence of events that prevented an injury, damage or fatality. Based on this premise, some researchers (e.g., Boateng, Pillay & Davis 2019; Manuele 2009; Toellner 2001) often view near miss as a lagging indicator. Therefore, this study adopts the concept of a near miss as a lagging indicator. As a lagging indicator, a near miss is considered on an equal measurement scale with recordable accidents/injuries (Hinze, Thurman & Wehle 2013). This identical synergy led to the refinement of the "number of accidents" construct into "number of accidents/injuries and near misses" in research reported by Hon, Chan & Yam (2014).

In effect, both leading and lagging indicators can assist organisations to ascertain the success of their safety programs (Cooper & Phillips 2004). Several measures of safety performance offer more expedient grounds for the improvement of targeted OHS management strategies (Lingard, Wakefield & Cashin 2011). Hon, Chan & Yam (2014) developed self-reported measurable items for near misses and injuries in line with the existing injury-reporting requirement of the Labour Department. Considering the biases related to self-reports, as well as the need to eliminate unit-level discrepancy errors, this study adopts the co-workers' reports of near misses and injuries by modifying Hon, Chan & Yam (2014) items. The next section discusses how to measure safety performance/behaviour.

2.4.3 Measuring safety performance

Earlier studies mostly used accident statistics to directly measure safety performance (Hon, Chan & Yam 2014). Later, this indicator (number of accidents) was defined as "number of accidents/injuries and near-misses" (Hinze, Thurman & Wehle 2013; Hon, Chan & Yam 2014). The amalgamation of accidents and injuries is suggestive of how frequently definitions of accidents are confounded with injuries (Christian et al. 2009; Jiang, Lavaysse & Probst 2019). These indicators have mostly been effective in a national context and good for strategic planning (Ghodrati et al. 2018). These metrics have also provided contractors with information for comparing safety performance with other organisations and projects in a project portfolio. Insurance companies and facility owners have extensively used these lagging indicators (Hinze, Thurman & Wehle 2013). However, the past years have witnessed a shift from lagging to leading indicators in OHS evaluations (Jiang, Lavaysse & Probst 2019; Mohamed 2002; Shen, Ju, et al. 2017). This has often been attributed to the ineffectiveness of lagging indicators since they have been criticised as evaluating system failures, and hence seem to have little predictive value (Cooper & Phillips 2004). For example, lagging indicators such as accident/injury rates show the things that went wrong or accidents/injuries that have occurred in the past. Accordingly, lagging indicators measure the lack of safety rather than the presence of safety (Arezes & Miguel 2003).

As a result, recent empirical works have often focused on measuring safety behaviour as a means of evaluating safety performance. The use of safety behaviour as a replacement for accidents/incidents indices for monitoring safety performance of organisations is instrumental in improving the safety of a complex system and preventing accidents/injuries in an anticipatory way (Mohammadfam et al. 2017). Regardless of these merits, a probable grave shortfall related to leading indicators is that the correlation between specific leading indicators and the outcome measures is usually unknown (Lingard, Wakefield & Cashin 2011). For instance, managers may not know to what degree the number of workers who have received safety incentives predicts the occurrence of lost time injuries or near misses. Furthermore, the assessment of leading indicators involves a robust and reliable review process that may be missing in less advanced firms (Hallowell, Bhandari & Alruqi 2019). These indicators are further vulnerable to devious influences to uphold performance (Oswald et al. 2018).

Accordingly, the validity of leading indicators is sometimes queried (Lingard, Wakefield & Cashin 2011). As a consequence, leading indicators are recommended for use in addition to (rather than in place of) lagging indicators (Department of Employment and Workplace Relations 2005). Multiple measures of safety performance offer a more useful basis for the development of targeted OHS management strategies (Lingard, Wakefield & Cashin 2011). Therefore, this study uses both lagging and leading indicators to provide a catalyst for valid, reliable, and rigorous measures of safety performance/outcomes (see Figure 2.2). After identifying these measures, the key existing concepts in the study are examined to know their associations with each other and the corresponding theories underpinning these linkages.

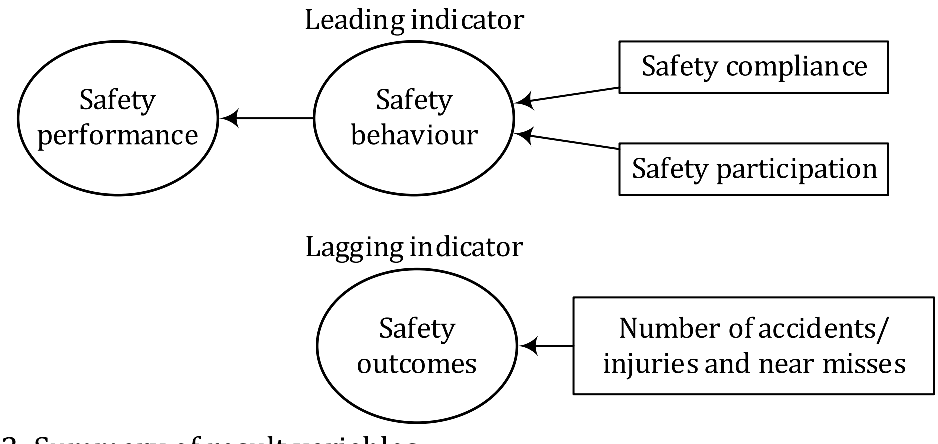

Figure 2. 2: Summary of result variables

2.5 The Nexus between Safety Climate, Safety Behaviour and Safety Outcomes

Traditionally, the concept of safety climate is theorised to have associations with safety behaviour and safety outcomes. Social exchange theory (Blau 1960) and expectancy-valence theory (Vroom 1964) provide the underlying linkages among these concepts (Neal & Griffin 2006; Zohar 2008). The theory of social exchange is among the top influential conceptual positions for discerning OHS behaviour (Cropanzano & Mitchell 2005). According to the social exchange theory, when individuals perceive that their organisation values their welfare, they will cultivate an inherent commitment to give back by exhibiting behaviour that benefits their organisation (Neal & Griffin 2006). These exchanges operate on the principles of reciprocity (Cropanzano & Mitchell 2005). Organisations can thus, form an atmosphere that promotes safety performance by prioritising workers (Mearns et al. 2010). As such, organisations need to encourage activities that express their support for employees (Hofmann & Morgeson 1999). This framework of social exchange provides the quid pro quo among agents (e.g. manager, supervisor, workers) within an organisation, as it forms a norm of reciprocity which in turn breeds desired behaviour and outcomes.

In a similar vein, the expectancy-valence theory posits that workers will be motivated to adhere to safety procedures and partake in safety actions if they perceive that this behaviour will lead to valued outcomes (Neal & Griffin 2006; Zohar 2000). From this premise, motivation serves as a link among expectancy, instrumentality, and valence (Ford & Tetrick 2008; Hon, Chan & Yam 2014; Vroom 1964). Expectancy suggests that the effort towards a certain behaviour will lead to that behaviour (Andriessen 1978; Waring 2015), whereas valence is the reward or relevant outcome for that behaviour. Hence, valence is subjective, or the degree to which these outcomes are valued by the individual (Ford & Tetrick 2008; Lingard & Rowlinson 1998). Instrumentality denotes the employee's belief in attaining the reward/valence as assured by management (Hon, Chan & Yam 2014; Vroom 1964). To this end, the rate and intensity with which an organisation observes and acts on safety matters define the expectancy valence related to safe or unsafe behaviour (Zohar 2000). Safety climate therefore informs behaviour-outcome expectancies (Beus et al. 2010; Zohar 2014; Zohar & Luria 2003). For example, when "management expresses concern if safety procedures are not adhered to, MgtCommit_2", workers tend to exhibit behaviours they perceive as being desirable in achieving the expectancies of the organisation such as "workers ensuring the highest levels of safety, SafCom_3" and "workers using all the correct safety procedures for carrying out their job, SafCom_2".

Meta-analytic evidence demonstrates that favourable safety climates are positively correlated with increased levels of safety performance/safety behaviour and inversely related to safety outcomes (e.g. accidents/injuries) (cf. Alruqi, Hallowell & Techera 2018; Beus et al. 2010; Christian et al. 2009; Nahrgang, Morgeson & Hofmann 2011). This inverse relationship between safety climate and accidents/injuries was a significant direct association (Nahrgang, Morgeson & Hofmann 2011). Specifically, group and organisational safety climates were more significantly related to accidents and injuries than psychological climates, with group safety climate having the strongest correlation with accidents and injuries (Christian et al. 2009).

On the other hand, safety performance was directly associated with accidents and injuries (Christian et al. 2009). Adopting this premise, unsafe behaviour would result in an accident (Reason 1990; Xia et al. 2020). Numerous meta-analyses (e.g. Beus, Dhanani & McCord 2015; Christian et al. 2009; Clarke 2010, 2012; Nahrgang, Morgeson & Hofmann 2011) have confirmed this relationship at the individual level (Beus, McCord &

Zohar 2016). However, there is far less evidence at the group level (Beus, McCord & Zohar 2016). The few studies that have been done at the group level have mostly reflected findings from the individual level of analysis (Beus, McCord & Zohar 2016). Safety climate is also significantly linked with safety compliance (Nahrgang, Morgeson & Hofmann 2011) and safety participation (Clarke 2006b). As a result, safety climate has been regarded as a robust predictor of subjective (e.g. safety behaviour) and objective (e.g. accidents/injuries) safety outcomes (Jiang, Lavaysse & Probst 2019; Zohar 2014). From these discussions, the climate→behaviour→accident model is assessed while considering the level of analysis and co-workers' agent point of view. These in agreement with earlier discussions lead to three initial hypotheses:

Hypothesis 1: Workgroup safety climate will be positively related to co-workers' safety behaviour.

Hypothesis 2: Co-workers' safety behaviour will be negatively related to co-workers' safety outcomes.

Hypothesis 3: Co-workers' safety behaviour will mediate the relationship between workgroup safety climate and co-workers' safety outcomes.

2.6 Demand for Safety Interventions

Empirical findings from a recent longitudinal study (data ranging from 2001 to 2013) gave partial support to the notion of utilising safety climate as a predictor of future safety outcomes (cf. Gilberg et al. 2015). There may also be additional factors influencing workers' safety behaviour (Barbaranelli, Petitta & Probst 2015). Owing to this, a recent systematic review by Boateng, Davis & Pillay (2019) revealed 100 factors influencing safety behaviour in the construction industry. Likewise, and contrary to the majority of the literature, studies provided by Glendon & Litherland (2001) concerning the construction industry revealed no relationship between safety climate and safety behaviour. Further, meta-analytic evidence by Clarke (2006b) found a weak correlation between safety climate and safety outcomes such as accidents and injuries. Accordingly, the climate-behaviour-accident route is not as straightforward as is sometimes presumed (Cooper & Phillips 2004). Notwithstanding the importance of safety climate in the prediction of workplace accidents, the dimensionality of safety climate and its component structure remains disputed (Alruqi, Hallowell & Techera 2018; Bosak, Coetsee & Cullinane 2013; Zohar & Luria 2003). This suggests that the mechanisms required to accurately yield a full picture of safety behaviour and related outcomes have not been well captured.

Considering these, Zohar (2010), 2014) suggested that it is time to proceed to a subsequent chapter of research in which safety climate concepts are improved by examining their association with antecedents, moderators and mediators, and in addition their link with additionally established constructs. Similar calls had earlier been made on behavioural safety research by Krispin & Hantula (1996). As several studies including Barling, Loughlin & Kelloway (2002); Zohar & Luria (2005) have shown, there is no direct relationship between safety climate and safety behaviour (Fugas, Silva & Meliá 2012). In particular, a third variable effects could explain some of the relationships between safety-related variables and outcomes (Christian et al. 2009). As a result, Wirth & Sigurdsson (2008) suggest that an intervention is needed to improve the safety behaviour of employees. However, despite extensive research demonstrating that safety climate influences safety performance and outcomes, no suitable research has been recognised in terms of interventions to achieve a better safety climate (Huang, Chen & Grosch 2010). There is, therefore, a dearth of safety climate studies testing intervention strategies intended to improve safety climate (Zohar 2014). As a consequence, there has been a call for research to identify interventions that aim at augmenting safety climate (Huang, Chen & Grosch 2010) as a means of providing better predictions of safety-related outcomes and performance.

Research by Robson et al. (2001); Zaira & Hadikusumo (2017) identified several interventions, although these are yet to be included in the climate-behaviour-outcome fraternity. Fortunately, these safety interventions are relevant for integration into a conceptual model as effect-modifying or confounding variables (Robson et al. 2001). Accordingly, there is the need for an intervention to improve an understanding of the link between safety climate and safety behaviour (Boateng, Davis & Pillay 2020). Zohar (2014) posits that these interventions consist of a mix of techniques targeted at reducing actual unsafe behaviour while increasing proactive safety behaviour (Fugas, Silva & Meliá 2012). Besides instituting safety interventions, such actions could result in a decline in accidents rates and accompanying expenses (Cooper 1998).

Drawing from social exchange theory, in an organisation that continually and sincerely caters for their workers' welfares, a communal agreement may emerge where the workers attempt to reciprocate by contributing to the perceived organisational goals (Törner 2011). In this respect, investments in OHS have a strong relationship with safety commitment, climate, and worker safety compliance (Mearns et al. 2010). The social exchange theory explicates associations between the worker and employer as an exchange of valued resources (Mearns et al. 2010). According to the resource theory (Foa & Foa 1980; Foa & Foa 1974), six kinds of resources function present within these exchanges: money, information, status, love, goods, and services. This suggests that the provision or implementation of certain safety interventions in the form of such resources by an organisation is contingent on its employees' ability to reciprocate, encourage and cultivate desired behaviour. To this end, the concept of a social exchange relationship is an intervening variable (Cropanzano & Mitchell 2005).

2.7 Safety Intervention: Definitions and Practices

Safety intervention is a move to modify or introduce practices to augment safety (Oyewole & Haight 2009; Robson et al. 2001). These interventions tend to alter workplace safety procedures, policies, structures, and the organisation itself (Robson et al. 2001). A key consequence of a safety intervention is its potential to change unsafe behaviour to safe behaviour (Neal, Griffin & Hart 2000). Robson et al. (2001) propose two safety interventions i.e. technical and human, whereas Zaira & Hadikusumo (2017) suggest three interventions by including management safety interventions. Likewise, Shakioye & Haight (2010) also suggest two interventions, being management and technical level safety interventions.

Management safety interventions are the top management strategies and safety managerial actions (Robson et al. 2001; Shakioye & Haight 2010; Zaira & Hadikusumo 2017). These include “safety policy”, “safety objectives”, “safety organisation”, “safety standard”, “management worker interaction”, “safety records”, “incident and accident, analysis, and prevention”, “in-house safety rules and regulations”, “contracting strategy”, “safety information management and feedback”, “safety audit on overall safety management system”, and “reviewing and implementing safety programmes” (Zaira & Hadikusumo 2017).

Technical safety interventions suggest methods that ensure a safe working atmosphere (Robson et al. 2001; Shakioye & Haight 2010; Zaira & Hadikusumo 2017). These interventions alter the organisation, design or workplace environment (Robson et al. 2001). Zaira & Hadikusumo (2017) identified such interventions as “workplace safety inspections", "personal protective equipment programme", "safe work practices/safe operation procedures", "safety equipment availability and maintenance", "implementation of safety inspections", "scheduled maintenance for all machinery and equipment", "movement control and use of hazardous substances and chemicals, safety process control programme", "emergency response preparedness", "designing safe temporary structure for construction", and "implementation of safety permits for high risk operations".

Human safety intervention denotes methods used to change human understanding and reasoning concerning safety practices that directly impact the employee (Robson et al. 2001; Shakioye & Haight 2010; Zaira & Hadikusumo 2017). Also, they modify attitudes, motivation or behaviour associated with safety (Robson et al. 2001). Human safety interventions comprise "behavioural-based safety programme", "safety training", "safety inductions for new workers", "safety awards, safety promotion, safety incentives", "safety supervision", "safety awareness programme, safety campaigns, safety knowledge programme, safety education", "safety information, safety bulletin boards", "requisite safety expertise for high-risk operations", "job hazard analysis", "daily tailgate, toolbox meeting" and "penalty, accident repeater punishment programme" (Zaira & Hadikusumo 2017).

Table 2. 1: Types of safety interventions

Management	Technical	Human
Safety policy	Workplace safety inspections	Behavioural-based safety programme
Safety objectives	Personal protective equipment programme	Safety training
Safety organisation	Safe work practices/safe operation procedures	Safety inductions for new workers
Safety standard	Safety equipment availability and maintenance	Safety awards, safety promotion, safety incentives
Management worker interaction	Implementation of safety inspections	Safety supervision

Safety records	Scheduled maintenance for all machinery and equipment	Safety awareness programme, safety campaigns, safety knowledge programme, safety education
Incident and accident, analysis, and prevention	Movement control and use of hazardous substances and chemicals, safety process control programme	Safety information, safety bulletin boards
In-house safety rules and regulations	Emergency response preparedness	Requisite safety expertise for high-risk operations
Contracting strategy	Designing safe temporary structure for construction	Job hazard analysis
Safety information management and feedback	Implementation of safety permits for high-risk operations	Daily tailgate, toolbox meeting
Safety audit on overall safety management system		Penalty, accident repeater punishment programme
Reviewing and implementing safety programmes		

Source: Zaira & Hadikusumo (2017)

2.7.1 Considerations for choosing a safety intervention

In selecting a suitable safety intervention, several factors must be evaluated, since each country is unique (Ramli, Mokhtar & Aziz 2014). For instance, diverse features of the construction industry, such as a majority of the workers on site coming from different cultural backgrounds, need a study to identify the kind of intervention that is suitable to stimulate safe behaviour within a certain region (Zaira & Hadikusumo 2017). Empirical research by Loosemore et al. (2019a) also demonstrated the role of institutional context and cultural relativism in influencing safety climate perceptions among construction industries in Australia and Indonesia. An emblematic attribute of the construction industry is the inevitable cultural diversity among the workforce (Feng 2014; Loosemore et al. 2010). Interventions directed at promoting safety behaviour at construction sites should be more effective when they consider social identity concerns (Andersen et al. 2015).

Safety studies have indicated that unsafe behaviour prevails during work activities for which risk is unduly downplayed (Zohar 2002b). In other words, unsafe behaviour occurs when workers tend to unjustifiably assign less significance to risks associated with their jobs. As a result, perceptions of risk are usually believed to be key contributing factors in safety behaviour (Caponecchia & Sheils 2011). In view of this, two out of the three main causes of construction accidents have been attributed to (1) a worker deciding to continue working on a task even after recognising an existing unsafe condition, and (2) a worker determined to act in an unsafe way irrespective of preliminary conditions on the site (Abdelhamid & Everett 2000). In essence, at times workers continue to work in spite of signs of danger (Weber et al. 2018). As Love et al. (2017, p. 3) observe, "as the perception of risk increases, the greater the likelihood that people are mindful of safe behaviour". Perceptions of risk therefore play a major role in the selection of an intervention (cf. Cohen & Erev 2018). Thus, it is essential to manage construction safety risks and improve safety performance (Zou & Sunindijo 2013).

On the other hand, because of cost and time limitations, it is challenging to implement all safety intervention practices at the workplace (Oswald et al. 2020; Zaira & Hadikusumo 2017). Notably, ineffective interventions could result in "safety clutter". Safety clutter is "the accumulation of safety procedures, documents, roles, and activities that are performed in the name of safety, but do not contribute to the safety of operational work" (Rae et al. 2018, p. 195). Implementation of such ineffective interventions tends to drain valuable organisational resources. Hence, the choice of an appropriate intervention should play a substantial role in impacting workers safety behaviour. To this end, two key features of the construction industry are explored; specifically, national culture and decision making under risk and uncertainty. Afterwards, an appropriate intervention is selected that is sensitive to influence on the compliance and participation behaviour of workers while minimising accidents/injuries. That is, based on the two selected features of the construction industry, a suitable safety intervention is expected to make workers use all the necessary safety equipment to do their job, use the correct safety procedures during work, ensure the highest levels of safety, promote safety programs within their organisation, put in extra effort to improve safety, and voluntarily carry out tasks that help to improve workplace safety (SafCom_1 to SafePart_3).

2.7.2 National culture

A typical characteristic of the construction industry is the inevitable cultural diversity among the workforce (Feng 2014; Loosemore et al. 2010). Studies have shown that cultural uniformity concerning OHS does not exist in organisations (Lingard 2013). This diversity is common in construction, where productive work is completed in locations outside the organisation's setting (Lingard 2013). For instance, apart from the planning phase of a construction project, the actual physical infrastructure is built on the land acquired by the client of the project and not on the land where the construction organisation is located. Also, in Australia, about 20% of all employees are migrant workers (Department of Immigration and Multicultural and Indigenous Affairs), and it is estimated that migration will remain a source of labour supply for the construction industry, since the home-grown labour supply will be in decline as baby-boomers retire, participation rates plateau and growth in young employees falls (Loosemore et al. 2010).

The behaviour of workers in the construction industry is coated with and subject to the complex constellations of national culture (Richter & Koch 2004). Hofstede's cultural dimensions theory (Hofstede 1984) provides a framework that distinguishes national cultures and cultural dimensions, and their influence on organisations. As detailed in Hofstede (2001), the cultural dimensions represent fundamental problems of societies. These dimensions are power distance, uncertainty avoidance, individualism, masculinity, and long-term orientation (Hofstede 2001). Research by Hofstede, Hofstede & Minkov (2010) suggests that Italy is higher than the United States in both power distance and uncertainty avoidance, because power distance is linked with employee involvement in occupationally associated decisions (Mearns & Yule 2009). Thus, it is expected that employees in high power distance cultures may be less likely to be proactive in raising safety concerns with their supervisors compared to employees in low power distance cultures (Barbaranelli, Petitta & Probst 2015). Anglo cultures such as Australia are high in individualism and apt to accentuate the unique desires, concerns, and aspirations of people whereas Southern Asian cultures are more collectivist, underscoring the relevance of shared ideals and goals (Hofstede 2001). Considering that safety messages given by supervisors mostly take the form of group goals (Conchie & Moon 2010), workers in Southern Asian cultures such as China and Indonesia are more likely to have stronger compliance to the collective safety rules and regulations than those in the Anglo cultures such as Australia and the UK (Casey, Riseborough & Krauss 2015). For example, a recent comparative study by Loosemore et al. (2019a) on safety climate in Australia and Indonesia show that Australian construction workers are less likely to perceive that safety rules are useful and complied by all. This culture differences make Australian construction workers more independent and take safety initiative. Whereas the collective nature of the Indonesian construction workers suggest they often remind each other to work safely that their Australian workers (Loosemore et al. 2019b).

Apart from the individualistic nature of the Australian culture, the low power distance in the Australian society encourages workers to query their superiors on the practicality of OHS rules and procedures. Given this, Safe Work Australia (2015c) found that Australian construction workers feel that challenging safety rules in some cases is appropriate especially when seen as impractical to fulfil. Likewise, Burke et al. (2008) found that uncertainty avoidance moderated the effectiveness of safety training programs. Workers functioning in a more collective and higher uncertainty avoidance setting are more likely to have safety awareness and beliefs, which can lead to safe behaviour (Mohamed, Ali & Tam 2009; Yap & Lee 2020). Other studies, such as Goh & Binte Sa'Adon (2015) study conducted in Singapore demonstrate how variations in culture (other workers from Bangladesh, India, and China) cognitively influences the decision of workers to anchor their safety harness or not. Numerous studies further support the mounting evidence on the role of national culture in OHS (Casey, Riseborough & Krauss 2015).

2.7.3 Decision-making under risk and uncertainty

Aven & Renn (2009) defined risk as uncertainty about events or consequences, seen in association with the severity of the events or consequences. Globally, there is a growing recognition that construction workers' behaviour towards safety is influenced by their perception of risk (Alkaissy et al. 2020; Mohamed, Ali & Tam 2009). These perceptions serve as a source for daily decision-making, influencing the choice of unsafe or safe behaviour (Epstein 1994; Xia et al. 2017). Risk also inhibits growth toward working safely (Nahrgang, Morgeson & Hofmann 2011). Hence, it is imperative to fathom how risk is understood since interventions in unsafe behaviour greatly depend on a clear comprehension of how risk is perceived (Weber, Blais & Betz 2002).

There is, therefore, the need to contextually and independently examine the decision-making process to understand how workers perceive risk. In this regard, insights from Prospect theory (Kahneman & Tversky 1979) are utilised. This study uses the lens of Prospect theory because the decisions construction workers make regarding safety are bounded by risk and uncertainty in a high-risk environment, which can substantially influence the likelihood of accidents/injuries/fatalities, for not only the worker, but also co-workers, the passer-by, and the community. According to Prospect theory, people assign value to gains and losses rather than to final assets, and probabilities are replaced by decision weights (Kahneman & Tversky 1979).

An axiom of the theory suggests that people assign more value to (overweight) outcomes that are certain, with immediate benefits, relative to outcomes that are merely probable (Allais 1953; Kahneman & Tversky 1979). In other words, people tend to prefer outcomes with sure benefits in the short run to outcomes with delayed, unsure, or future dangers. For example, workers are likely to underweight rare negative outcomes (e.g. near misses, injuries, and accidents) of unsafe behaviour for the immediate benefits of unsafe behaviour (e.g. faster pace, general personal comfort, and lesser effort) and will often overweight those of safe behaviour (Zohar & Erev 2007; Zohar & Luria 2003). Further, workers usually protest that PPE is uncomfortable, exasperating to wear, and it slackens their pace when performing their assigned duties (Scott, Fleming & Kelloway 2014). In brief, given the relative rarity of injuries, they are less likely to occur even during the riskiest of behaviour, whereas the negative outcomes of safe behaviour are usually sure (Ford & Tetrick 2008).

These rare negative outcomes can be inferred from seminal work by Heinrich (1941) where 1 out of 15,000 safety violations resulted in an accident. More recent estimates put this figure even higher, suggesting that 30,000 violations (unsafe acts and/or unsafe conditions) will lead to 30 minor injuries or one fatality (Reason 1997; Zohar & Erev 2007). These ratios encourage the natural tendency to violate safety compliance because people tend to overweight recent outcomes when choosing among action choices (Barron & Erev 2003b; Zohar & Erev 2007). This axiom remains functional in situations where there is a high likelihood of known or delayed future negative outcome. For example, workers are aware that there is a cumulative hearing loss from exposure to certain noise levels that becomes apparent ten or fifteen years later, yet there have been violations of safety regulations that require the use of ear protectors in noisy workplaces since, in the short run, it saves discomfort and may also improve performance through better detection of auditory signals (Zohar & Erev 2007). In a similar vein, research by Caponecchia & Sheils (2011) demonstrates that Australian construction workers believe that negative events, concerning OHS hazards on site, are less likely to occur to oneself than to others.

These insights play a significant role in whether to hold safety as a top priority in an individual organisation as well. For instance, a recent headline by the South China Morning Post (2019) read, "Construction on Hong Kong's Sha Tin-Central rail link allowed to proceed without required forms as workers were in a rush". Thus, when there is high pressure for production, management commitment to safety becomes negatively related to unsafe behaviour, irrespective of the priority level of safety (Bosak, Coetsee & Cullinane 2013). Providing a root causality analysis to this case, insights from Prospect theory suggest that a present-future trade-off caused the workers' rush. In other words, the immediate benefits (such as receiving management fees and meeting production deadlines) overweighed the future/unlikely dangers (such as injuries/fatalities) influencing the decision to proceed without the required safety forms. Elaborating on future/unlikely dangers, the MTR Cooperation CEO insisted, "there was no evidence so far suggesting the station was unsafe", and "currently, we see no evidence of there being any structural integrity issues".

Workers' decisions to behave unsafely can, in certain conditions, be considered a reasonable reaction to prevailing conditions (Lingard & Rowlinson 1997). By way of the principle of least effort, workers are likely to prioritise circumstances in which management confronts contending work demands, such as safety versus productivity, and communicates to them about what is prioritised, esteemed and encouraged (Ashforth 1985; Zohar 2003). For instance, WorkCover Queensland (2019) reported that work pressures usually drive workers and managers to knowingly perform tasks without considering proper safety mechanisms. From these premises, unsafe behaviour should be expected where unsafe, but speedy, construction work is rewarding for both the worker and contractors (Lingard & Rowlinson 1997).

2.7.4 Choice of safety intervention

The safety behaviour of construction workers is a complex phenomenon. Managing workers from diverse cultural backgrounds, prone to decision-making in risky and uncertain environments, require suitable safety intervention practices to influence their safety behaviour. To ameliorate safety behaviour, it is essential to introduce an intervention that would increase the probable and recurrent gains of safe behaviour in the short run. Thus, such an intervention should be able to present frequent short-term rewards to overcome the propensity to underweight the future benefits of safe behaviour (Zohar & Erev 2007; Zohar & Luria 2003). The primary strategy that meets these criteria is behaviourally based safety (Geller, Roberts & Gilmore 1996), which is a practice of human safety intervention. Behaviour-based safety (BBS), also known as the behavioural theory of accident causation, refers to the methodical application of psychological enquiry into human behaviour (Choudhry, Fang & Mohamed 2007). In BBS, the focus is centred on particular safety-related behaviour that is mostly performed by workers

(Krause, Hidley & Lareau 1984). Human safety interventions therefore include practices to change human knowledge, competence, attitude, motivation, rewards and incentives or behaviour related to safety (Robson et al. 2001). As such, organisations should concentrate on interventions that will accrue safety knowledge to increase safety compliance and participation (Amponsah-Tawaih & Adu 2016; Yu et al. 2021).

Additionally, there is a risk that well-driven interventions to augment safety, that do not consider a wider array of interrelating social-psychological aspects may fail, or even be counterproductive (Törner 2011). With technical safety interventions, the influence of new technologies that are aimed at improving safety may backfire (Cohen & Erev 2018), because the net effect of interventions that avoid or decrease accident expenditure is not always positive. Such interventions can lead workers to act as though they "forget to be afraid" (Cohen & Erev 2018). For example, workers may perceive that the implementation of some technical interventions (e.g. PPE) makes them immune to workplace risks and hazards leading workers to take more risks (Cohen & Erev 2018). Further, regardless of the extensive uses of PPE in construction and perpetual improvements in technological approaches to its availability, a common drawback of PPE is that it does not eliminate the hazards at its source (Holt 2008). To this end, it is widely acknowledged that construction OHS research should concentrate on the human aspect of safety to advance safety management (Zou & Sunindijo 2013).

Technical safety interventions at times fail to eliminate hazard vulnerabilities (Ford & Tetrick 2008). Two key ways have been suggested to overcome the limitations of other solutions such as the technical. First, improve the knowledge and skills required by workers to perform safe work, and second, organisations could augment safety behaviour by building an atmosphere that supports the motivation to participate in safe behaviour (Ford & Tetrick 2008). Owing to these, a bibliometric analysis of safety culture research (N=1789 publications) revealed that "a movement away from technical aspects towards more human aspects could be detected as a noteworthy change in research focus" (van Nunen et al. 2018, p. 248), suggesting that human safety interventions could effectively improve the safety behaviour of workers. Therefore, this approach is adopted in this study.

2.8 Measuring Human Safety Interventions

After reviewing a substantial amount of literature, Zaira & Hadikusumo (2017) identified 15 human safety interventions and developed a preliminary questionnaire. Items in their questionnaire were rated using a three-point Likert scale and then validated in the Malaysian construction industry, leading to an 11-item questionnaire for the construct. However, some key improvements could be added to the questionnaire to ensure high explanatory and predictive power, owing to reasons such as modification of the measurement instrument to align with particular features of the industry (Zhang, Lingard & Nevin 2015), for instance, from an agent's point of view (cf. Meliá et al. 2008; Zhang, Lingard & Nevin 2015). Moreover, the type of Likert scale, and institutional and cultural contexts could influence the size of the sieve-holes through which a question/item is maintained or removed. This study thus develops and validates the human safety intervention tool in the Australian context using a five-point Likert scale while considering the co-worker agent point of view.

Furthermore, the rendering of Zaira & Hadikusumo (2017) questionnaire items does not show the directional impact of the worded questions as they are not in sentences. This scenario could lead to potential bias, as workers may distinctively perceive different meanings to what is expected from them as questionnaire respondents.

Given these observations, Zhang, Lingard & Nevin (2015) recommend that considering the comparatively lower education level of construction workers and cognitively tedious efforts required, survey instruments developed within construction should eliminate negatively worded questions to ensure reliable and valid responses/data. Following this, improved Cronbach's alpha coefficients were attained when the researchers (i.e. Zhang, Lingard & Nevin 2015) deleted negatively word sentences. Therefore, this study places Zaira & Hadikusumo (2017) questionnaire items into positively worded sentences. In addition, double, or multiple options within a question, such as "safety awareness program, safety campaigns, safety knowledge program, safety education" are streamlined to eliminate ambiguity by using "one-question, one-idea" sentences.

Considering the call for research into testing safety climate with safety interventions (cf. Huang, Chen & Grosch 2010; Zohar 2014), it is projected that further research will be geared towards cross-pollination among these and other established constructs. In line with these discussions, it is of utmost significance that detailed surveys are developed and then administered occasionally to detect contemporary experiences of safety implementations (Wirth & Sigurdsson 2008).

2.9 Associations Among Human Safety Intervention Practices

Sensitivity analysis has revealed that safety attitude, safety knowledge, supporting environment, and motivation are the best predictors of safety behaviour at the construction workplace because a small change in their conditions corresponds to a change in the prospect of safe or unsafe behaviour (Mohammadfam et al. 2017). Human safety intervention practices, such as safety training, safety awareness programs, safety knowledge programs, safety education, safety information, and safety bulletin boards, are key to improving safety knowledge. Organisations can therefore invest in their OHS through multiple media and methods such as posters and leaflets (Mearns et al. 2010). Workers' voluntary actions, such as involvement in safety campaigns, endorse worker safety behaviour and support co-worker safety behaviour, hence offering a supportive environment for safety compliance and participation to thrive in. Because these activities encourage social ties and friendships, they need to be regarded as highly influential on performance outcomes (Zohar & Tenne-Gazit 2008). Furthermore, when management initiates safety campaigns, it informs workers about the primacy of safety over other competing company goals, and hence workers feel valued and appreciated (Törner 2011). As a result, a supportive environment is the most crucial factor in influencing workers' safety attitude (Mohammadfam et al. 2017).

The prevailing effect of safety attitude on construction workers' safety behaviour has been highlighted in numerous studies (Shin et al. 2014). Supervisors are chief players in realising a supportive environment, for the reason that when safety is a top priority for supervisors, it will be important for workers as well (Mohamed 2002). Therefore, to boost workers' safety attitudes, it is recommended that their participation in safety-related activities, such as hazard analysis, should be promoted and a supportive environment fostered (Mohammadfam et al. 2017). Similarly, during these interventions, patterns of supervisory relations (i.e. safety practices) are modified to change the loss/gain ratio of workers' safety behaviour (Zohar & Luria 2003). Hazard analysis is carried out on a worker's task and particular behaviour depicting safe and unsafe practices are identified (Lingard & Rowlinson 1997). However, the level of supervisors' involvement in providing a supportive environment further dwells in the policies informing their roles, which are determined by management. Consequently, a management commitment to safety is crucial in moulding workers' safety attitudes (Mohammadfam et al. 2017; Singh & Misra 2020). Workers therefore pay attention to these established policies, as they are perceived as a pattern providing information about desired behaviour at the workplace (Zohar 2000). This suggests that worker behaviour is immensely influenced by social norms (i.e., perceived workgroup norms and perceived management norms) and culture (Choi, Ahn & Lee 2017).

Nonetheless, caution is counselled, as social norms erode if there is no stabilising presence, such as social sanctions (Heckathorn 1989). Drawing insight from Prospect theory once again, it is possible for workers to violate the rules and policies that are declared by management and implemented by supervisors in a supportive environment. In this case, a social sanction, such as a penalty or, accident repeater punishment program, provides checks and balances in the management of workers' safety behaviour. Thus, rewards and punishment build an environment in which workers are encouraged to exhibit targeted behaviour (Guo, Goh & Le Xin Wong 2018). In BBS, motivational acts such as safety incentives are put in place to foster desired safety behaviour, and then workers' safety behaviour is observed. A BBS program therefore encourages behaviour modification (Molenaar, Park & Washington 2009). Thus, such motivational interventions beyond engineering developments are essential to improve safe behaviour and minimise accidents (Ford & Tetrick 2008).

Consistent with social exchange theory, when an organisation is thought to fulfil its duties, care for workers fairly, and offer valued services and benefits, workers reciprocate with higher levels of commitment and performance (Mearns et al. 2010). A favourable safety climate increases the impact of interventions designed to encourage safe behaviour and minimises accidents and injuries (Hofmann, Burke & Zohar 2017). Consequently, human safety interventions effectively nudge or boost workers' safety behaviour to flourish in a dynamic and risky environment. Likewise, these interventions could improve safety climate (Huang, Chen & Grosch 2010), leading to a better prediction of safety-related outcomes and performance. However, as Huang, Chen & Grosch (2010, p. 1422) observe in their special issue on new developments in the conceptualisation, theory and research of safety climate, “no appropriate studies were identified in terms of interventions to improve safety climate”. Moreover, the formation of a positive workgroup safety climate involves effort and safety-related interventions (Cheung & Zhang 2020). Therefore, interventions targeted at strengthening safety climate are needed (Huang, Chen & Grosch 2010), and more research is required to fathom the antecedents of safety climate (Ford & Tetrick 2008). These and earlier discussions lead to three hypotheses concerning the relationship between workgroup safety climate, human safety interventions, and workers’ safety behaviour:

> *Hypothesis 4:* Human safety interventions will be positively related to workgroup safety climate.
>
> *Hypothesis 5:* Human safety interventions will be positively related to co-workers’ safety behaviour.
>
> *Hypothesis 6:* Human safety interventions will moderate the relationship between workgroup safety climate and co-workers’ safety behaviour.

2.9.1 Influence of organisational and group safety climates

Empirical evidence corroborates the significant role played by supervisors in the construction industry (Lingard, Pirzadeh & Oswald 2019). They provide feedback to workers on practices such as rewards, achievement of goals, or behaviour reinforcement (Kapp 2012). Consequently, supervisors’ competencies have been identified as key in facilitating the effectiveness of OHS practices (Finneran et al. 2012; Yiu, Sze & Chan 2018), on the basis that supervisors make micro-decisions daily as they implement management policies and procedures within operational activities (Hofmann, Burke & Zohar 2017). In other words, supervisors make choices about how and which interventions to implement (Zohar 2008).

Likewise, because supervisors have frequent interactions with workers, their responses to safety are important cues used by workers to determine the priority and value of safety practised in their workgroups (Cheung & Zhang 2020; Fang, Wu & Wu 2015; Zhang, Lingard & Nevin 2015). Based on social information processing theory (Salancik & Pfeffer 1978) together with social learning theory (Bandura & Walters 1977), which postulates that individuals' attitudes and behaviour are affected by social cues in their close social environment, supervisors can communicate the value of safety throughout the workgroup (Kessler et al. 2020). As such, how supervisors lead, and the environment they create for safety to thrive, shapes the perceptions workers form about how the organisation supports and rewards safety. Therefore, the supervisory environment could serve as an antecedent to the workgroup safety climate.

On the other hand, considering that safety interventions influence the formation of a positive workgroup safety climate (Cheung & Zhang 2020), these could act as influences between supervisory environment and workgroup safety climate. Nevertheless, the role that human safety interventions play in how supervisory environment affects workgroup safety climate is unclear. This discussion leads to the four hypotheses:

Hypothesis 7: Supervisory environment will be positively related to human safety interventions.

Hypothesis 8: Supervisory environment will be positively related to workgroup safety climate.

Hypothesis 9: Human safety interventions will mediate the relationship between supervisory environment and workgroup safety climate.

Hypothesis 10: Human safety interventions will moderate the relationship between supervisory environment and workgroup safety climate.

Drawing insights from role theory, it is suggested that supervisory roles are moulded by the needs of the system in which they are embedded (Katz & Kahn 1978; Stryker & Serpe 1982). This line of reasoning suggests that the magnitude of organisational expectations and goals communicated to supervisors influences the degree to which they are viewed as representatives of the organisation and affirms their assigned duties (Eisenberger et al. 2010; Vandenberghe, Bentein & Panaccio 2017; Venkataramani, Green & Schleicher 2010). Following this, when management emphasises safety as a priority, supervisors tend to be more concerned with safety issues (Cheung & Zhang 2020; Li et al. 2021; Zohar 2002a), for the reason that the expectations communicated by management will affect supervisory practice (Bacharach, Bamberger & Sonnenstuhl 1996; Zohar 2002a). This management communication-supervisory environment association is important, because supervisors are traditionally the nearest organisational link to the workers, and can communicate the organisation's goals directly to them (Pati & Kumar 2010). These arguments lead to the following hypothesis:

Hypothesis 11: Management communication will be positively related to the supervisory environment

Once safety rules and procedures are instituted, management can communicate them to make workers aware of these fundamental organisational priorities (Alruqi, Hallowell & Techera 2018). These policies, rules and procedures must be perceived by workers as applicable, reasonable, and useful (Zou & Sunindijo 2015). Supervisors execute and enforce these policies and associated procedures through frequent decisions and interactions with workers (Zohar 2008). As such, supervisors can mould the perceptions of workers about their immediate social contexts (Kessler et al. 2020). This downward communication reflects safety rules and goals from management (Khawam & Bostain 2019; Zamani, Banihashemi & Abbasi 2020). How management communicates current safety rules and procedures ought to be evaluated, leading to the following hypothesis:

Hypothesis 12: Current safety rules and procedures will be positively related to management communication.

Management commitment is a major contributor to the success of safety programs (Zohar 1980). Following this line of reasoning, a recent study by Yiu, Sze & Chan (2018) found that management commitment is a critical success factor driving the implementation of safety management systems because top management has the power to assign resources and enforce the company's policies (Sunindijo & Zou 2012). However, to realise these developments the prevailing policies and procedures must be favourable enough to nurture safety success throughout the organisation. These safety rules, policies, and procedures are established by management (Zohar 2008). The rules and procedures set by an organisation draw the boundaries for expected behavioural norms (Zohar & Luria 2005). Management commitment to safety further improves compliance with safety rules and procedures (Wu et al. 2015). This study expects management commitment to influence current safety rules and procedures, suggesting the following hypothesis:

Hypothesis 13: Management commitment will be positively related to current safety rules and procedures.

Figure 2.3 presents the research framework which summarises the study hypotheses discussed in this thesis. The framework places HSIs as an effect-modifying construct that could minimise poor safety outcomes. The model addresses the second objective of this study and provides the theoretical justification for pursuing the fourth objective. The model assumes that to reduce the number of accidents/injuries and near-misses, initially, management commitment would be positively related to current safety rules and procedures. Then current safety rules and procedures would be positively associated with management communication. Management communication would also be positively related to the supervisory environment. Next, supervisory environment would be positively linked with HSIs and workgroup safety climate. HSIs would be positively associated with workgroup safety climate. Considering these linkages, the study expects that the relationship between supervisory environment and workgroup safety climate is mediated and strengthened by HSIs. Afterwards, workgroup safety climate would be positively related to co-workers' safety behaviour. The study proposed that HSIs would moderate the relationship between workgroup safety climate and co-workers' safety behaviour. HSIs are also suggested to have a positive relationship with co-workers' safety behaviour. Next, co-workers' safety behaviour would mediate the relationship between workgroup safety climate and co-workers' safety outcomes. Finally, the study proposes that in the event where co-workers' safety behaviour is admirable, there would be a reduction in co-workers' poor safety outcomes.

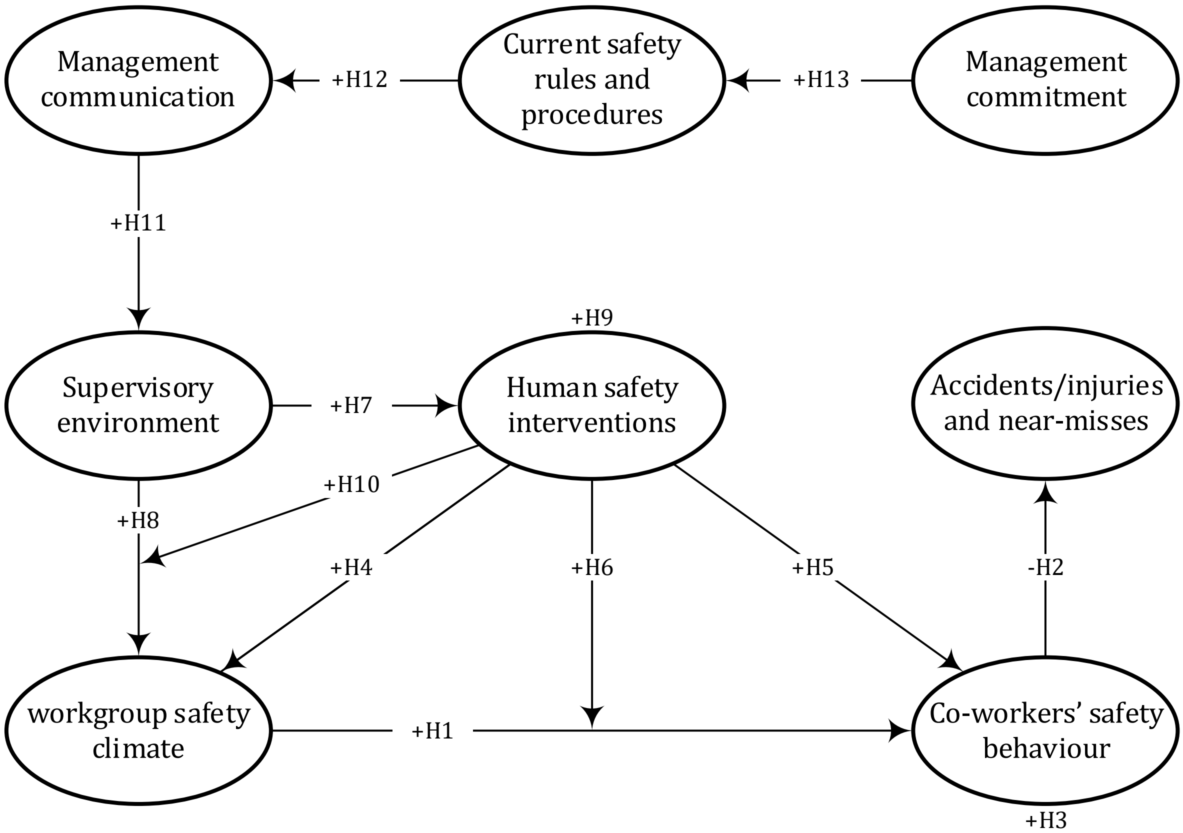

Figure 2. 3: Summary of research hypotheses and theoretical framework.

2.10 Accidents/Injuries and Near-Misses: An Antecedent of Workgroup Safety Climate

While considerable research has sought to study the influence of safety climate on safety performance and outcomes, few studies have investigated how climate perceptions are formed in construction. Put simply, what predicts safety climate in construction? How do workers form perceptions concerning the value of safety in their organisation? In this regard, how employee cognition is developed remains less understood (Huang, Chen & Grosch 2010; Lingard, Pirzadeh & Oswald 2019; Newaz et al. 2019b; Schwatka, Hecker & Goldenhar 2016; Zohar 2010). It is therefore not clear what contributes to the development of group safety climate (Lingard, Cooke & Blismas 2010b).

Two fundamental antecedents to support the development of climate perceptions are symbolic social interaction and supervisory leadership (Ostroff, Kinicki & Tamkins

2003; Zohar 2010). In terms of leadership, meta-analytic evidence suggests that transformational leadership is not very efficient in influencing safety compliance (Clarke 2013; Kessler et al. 2020). Among other studies in the construction industry, researchers such as Lingard, Pirzadeh & Oswald (2019) suggest that the communication network density of subcontracted crews is an influence on workgroup safety climate. Newaz et al. (2019b) also argued that the psychological contract between supervisors and workers offers a superior prediction of how safety climate is developed. Andersen et al. (2018) investigated how social identity within the workgroup affects safety climate. In other sectors, Zohar & Tenne-Gazit (2008) investigated the degree to which transformational leadership and group interactions predict safety climate strength among military platoons. Zohar & Luria (2004) further explored the attributes of managerial practice as an antecedent of group safety climate among infantry soldiers.

Injuries have also been considered as an antecedent of safety climate since they provide information about the workplace (Beus et al. 2010). When injuries occur, they are indications of the fundamental safety climate in an organisation (cf. Spence 1973). This line of reasoning denotes that, workers' observations of previous injury-related occurrences and experiences will affect their views of safety practices, procedures, and policies (Schneider & Reichers 1983). Similarly, whereas empirical evidence shows the influence of safety climate on accident occurrence at the group level (cf. Andersen et al. 2018), the possible reciprocity of this occurrence as an influence on worker perception concerning safety as an organisational priority at the workgroup level is unclear. Meta-analytic evidence shows that injuries are predictive of organisational-level safety climate (Beus et al. 2010). Thus, there could be a difference in how a certain level of injuries affects a level of climate perceptions.

According to Beus, McCord & Zohar (2016, p. 367), "injuries could be conceptualised as antecedents of safety climate perceptions". Hence, there is the potential that the outcomes of climate perceptions can, in turn, serve as predictors of climate (Schneider et al. 2017; Schneider, White & Paul 1998). Grounded in these theorisations, and the notion that accidents and injuries are synonymous (cf. Christian et al. 2009; Cooper et al. 1994; Ostroff, Kinicki & Muhammad 2013; Visser et al. 2007), this study seeks to examine the role of co-workers' safety outcomes as an antecedent of the workgroup safety climate, formulated as:

Hypothesis 14: Co-workers' safety outcomes will be negatively related to workgroup safety climate.

Figure 2.4 presents another research hypothesis proposed in this study. The study hypothesises that co-workers' safety outcomes would be negatively related to workgroup safety climate in construction projects. This model provides a theoretical basis for examining the fifth objective of this study.

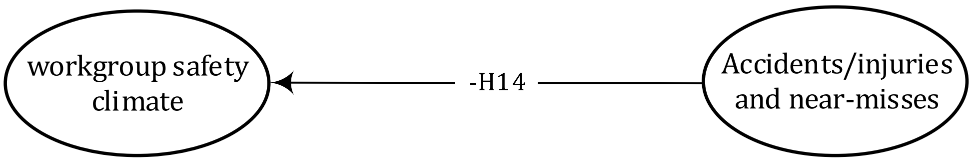

Figure 2. 4: Further research hypothesis

2.11 Chapter Summary

This chapter presented a literature review on safety climate, safety behaviour, safety outcomes, and human safety interventions. It addresses the first and second objectives of the research. This was achieved by, first, introducing the state of safety in the Australian construction industry. The chapter then provided an in-depth review on safety climate concerning themes such as its origin, definitions, importance, and levels of climate analysis. From this, an argument was presented for multilevel analysis of safety climate, while substantiating the need for integrating co-workers as important agents of influence on other workers safety perceptions, and as a source of contributing to a more homogenous view on safety matters. A referent-shift approach for aggregating climate assessments was then chosen for the study following an appraisal of alternative techniques. An industry-specific safety climate instrument was deemed suitable for measuring safety climate. Each construct in the industry-specific instrument was then categorised under either the group or organisational safety climate. As an outcome variable, safety behaviour was then reviewed, concerning its distinctiveness from safety outcomes, types, and measures. The underlying associations among safety climate, safety behaviour and safety outcomes were theorised, which led to three initial hypotheses of the study.

Afterwards, the chapter presented the literature on safety interventions and the resulting research hypotheses. Using social exchange theory, the chapter provided the theoretical grounds for the need to implement safety interventions as a means to strengthen the association between the perceptions workers form about safety priority and their safety behaviour. However, the choice of a particular intervention for this purpose required some considerations. Given the uniqueness of the construction industry, the chapter employed national culture and decision making under risk and uncertainty as the two crucial concerns. Based on these factors, HSIs were selected as the more appropriate interventions to improve safety compliance and participation. The need for a suitable measure of HSIs was then discussed. Afterwards, the chapter identified the association among the HSI practices and their link with workgroup safety climate, safety behaviour, and safety outcomes. This led to the development of ten hypotheses. These hypotheses in this chapter described the theoretical model for this thesis. The research methodology governing this research is thoroughly described in the next chapter.

3 RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the body of methods and principles influencing the research. Worldviews and techniques needed to address the research question are highlighted. In this respect, this section outlines the procedures for undertaking the research. To achieve the research goal, this chapter introduces the theoretical position of this study. It then selects an appropriate research design to examine the relationships within the theoretical model. A research strategy is then devised to increase the chances of addressing the research question. Afterwards, the geographical context, study population and participants of the research are described. The sample for the study is then determined, followed by the sampling technique. The chapter also presents the specific questionnaire instruments used for measuring the constructs in the study. A description of the process for collecting data for this research is also provided while paying attention to ethical considerations. Lastly, matters concerning the analysis of data are addressed.

3.2 Philosophical Position

The philosophical position is a theoretic lens through which people view events (Fellows & Liu 2015). A theoretical stance tends to influence the approach to enquiry and discovery adopted in a study. Mir & Watson (2000, p. 941) describe a position as "…a characteristic set of beliefs and perceptions held by a discipline…". These sets of beliefs and perceptions guide research (Guba & Lincoln 2005). Four schools of thought about positions/paradigms/worldviews, as identified by Creswell (2009), are pragmatism, constructivism, participatory/advocacy, and postpositivism/positivist.

According to the positivist paradigm, "everything can be measured and, if only one knew enough, the causes and effects of all phenomena could be uncovered" (Walliman

2011, p. 175). In other words, this epistemological stance maintains that all events could be analysed using scientific methods. This philosophical view has a strong link to quantitative approaches (Borrego, Douglas & Amelink 2009; Fellows & Liu 2015). As such, the positivist supposition is more inclined to quantitative studies than qualitative studies (Creswell 2009). Following this line of reasoning, knowledge can be simplified into discrete variables for hypothesis testing and theory verification.

On the other hand, constructivism is the opposite of deterministic philosophy. Thus, it is an approach that favours qualitative enquiry (Creswell 2009). This worldview perceives social occurrences, interactions and associated interpretations as being constantly revised or attained by social agents (Bryman 2008; Zou, Sunindijo & Dainty 2014). In this regard, this stance posits that reality is relative (Fellows & Liu 2015). The constructive paradigm follows the assumption that reality is fabricated by the actors involved thereby leading to complex opinions. As a result, this thinking postulates that the goal of an enquiry is to dwell as much as possible on the participants' opinions of the phenomena under investigation (Creswell 2003). From this anti-positivist epistemology, instead of commencing with a theory, researchers build a theory, or patterning of interpretation (Creswell 2009).

According to the participatory school of thought, scientific enquiries should be tangled with politics and political agenda (Creswell 2009). This view holds that the investigation coupled with such an agenda could alter the faith of the participants, involved institutions and the researcher as well (Creswell 2003, 2009). Theoretical positions within this knowledge claim community include feminist perspectives (Olesen 2000), racialized discourses (Ladson-Billings 2000), critical theory (Fay 1987), queer theory (Gamson 2000), and disability inquiry (Mertens 1998).

The pragmatic position suffices as the ideal worldview for mixed methods scientific enquiry (Teddlie & Tashakkori 2003). Pragmatism fuels a context-driven approach to research, for the reason that the capacity to address the research aim is of utmost importance to the pragmatist (Gelo, Braakmann & Benetka 2008; Howe 1988). Proponents of this paradigm are therefore concerned with "what works" (Patton 1990). With this view, "all hands are on deck". According to this philosophy, a mixed-method approach is engaged to address the research question (Creswell 2009).

Drawing insights from these discussions, this research adopts a postpositivist lens, as the goal of this study is to examine causes that affect outcomes under an umbrella of hypotheses using quantitative data that begins with a presupposed theory (such as social exchange).

3.3 Research Design

There are three types of research designs: quantitative, qualitative and mixed methods (Creswell 2009). These methods differ in terms of how data is collected and analysed. The quantitative method employs a "scientific method", whereby a preliminary investigation of theory and literature leads to concise aims and objectives with propositions and hypotheses to be tested (Fellows & Liu 2015; Popper 2014). This method is mostly characterised by applying deductive reasoning to connect theory and research, collecting numerical data, an inclination for a natural science perspective to explain social phenomena, and taking an objective stance towards social reality (Bryman 2008). Whereas the qualitative method focuses on words and meaning instead of numerical measurement in the gathering and assessment of data (Zou, Sunindijo & Dainty 2014). In qualitative design, open-ended questions are used to amass expressions from participants (Crotty 1998). With this method, the researcher usually makes knowledge claims grounded in the constructivist view (Creswell 2003).

The mixed-method approach integrates both quantitative and qualitative data at some phase of the research process into a single study (Ivankova, Creswell & Stick 2006). This research uses a quantitative research approach because the goal is to examine relationships among variables by evaluating some hypotheses built from theory using numerical data from closed-ended questions.

3.4 Research Strategy

The goal of the research strategy is to maximise the probability of attaining the study objectives (Fellows & Liu 2015). Researchers tend to reflect on their research designs as a critical consideration when selecting research strategies. Bell (2014) puts forward five research strategies: experimental, action, surveys, ethnographic, and case study. Surveys and experiments are associated with quantitative research; ethnography, case study, phenomenology, narrative, and grounded theory are linked with qualitative research; while triangulation, facilitation and complementary approaches are associated with mixed research design (Creswell 2003, 2009; Zou, Sunindijo & Dainty 2014). Considering that this research employs a quantitative research design, hence, by default, experiments or surveys could be more relevant for this study. Likewise, it invokes the postpositivist paradigm.

The experiment strategy of inquiry sets out to determine whether a particular treatment affects an outcome (Creswell 2009). This pursuit could be performed in a laboratory or a dynamic political, industrial, social or economic environment (Fellows & Liu 2015). These experiments seek to isolate and regulate each important circumstance determining the phenomena studied, and then monitors the influences when the circumstances are manipulated (Walliman 2011), whereas a survey strategy yields "a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population" (Creswell 2009, p. 12). Considering that this research intends to acquire data from a representative population (at a point in time) to understand the trends or influencing patterns among constructs, the cross-sectional survey strategy is deemed more fitting for this research.

3.5 Research Setting, Study Population and Participants

This section discusses the environment/location where the research was conducted. The section also provides information on the number of construction trade workers available within the selected location. Finally, the number of construction trade workers who participated in this study is presented.

3.5.1 Research setting

Five construction sites operating in New South Wales were used as the study setting. These sites were operated by Tier 1 and Tier 2 contractors, and/or their subcontractors. The construction sites were selected based on their present stages of work progress, in consultation with the timeline of this research project. At the pilot study level, two university departments were involved: Construction Management and Occupational Health and Safety.

3.5.2 Study population

"Study population" is a collective expression employed to define the overall sum of cases of the type that are the subject of the study (Walliman 2011). This designated population represents a subset of the overall population specific to the construction industry in New South Wales. For this research, the study population is the number of construction workers within New South Wales. Bankwest (2017) estimates this figure as 211,000 workers as of 2016.

3.5.3 Study participants

The study participants are the individuals who are representative of the study population, in order to generalise the results (Gelo, Braakmann & Benetka 2008). For this research project, a total of 317 (out of 350) construction workers were examined while considering the inclusion criteria. The participants were invited to participate if they:

- Worked in construction,
- Were 18 years old and above,
- Were involved in a trade, such as a roofer, carpenter, or painter, and
- Had at least one year of experience in the construction industry.

3.6 Sample Determination

Estimation of the sample size in this study is contingent on the type of inferential statistics used, i.e. Covariance-based Structural Equation Modelling (CB-SEM) and Variance-based Structural Equation Modelling (VB-SEM). Every case is unique, hence different sample sizes may be required for each model because the sample size is extremely dependent on the particular model (Chin 1998). Therefore, there is no simple rule concerning a sample size that fits all studies (Kline 2016). Notably, CB-SEM is a large sample tool (Ullman & Bentler 2003), particularly considering that covariances are prone to instability when estimated on small sample sizes. However, this prompts the question, how large should the sample size be? In addressing this concern, some heuristics have been recommended. Earlier studies such as Kline (1998), suggest 10 to 20 cases to an estimated parameter. Following this guideline, this study would need at least 110 cases to assess the SEM model. Later, Kline (2015) suggested 5 to 10 participants per variable, or at least 200 cases. This figure of 200 recommended cases serves as the lower limit for SEM sampling (Crowley & Fan 1997; Weston & Gore Jr 2006). On the other hand, Bagozzi & Yi (2012) suggest a minimum of 100 samples to be meaningful and preferably above 200.

A majority of the earlier arguments tend to satisfy the "*N:q* hypothesis" by Jackson (2003). According to Jackson (2003), investigators should consider minimum sample sizes in respect of the proportion of the number of cases (N) to the sum of model parameters that need statistical estimates (q). This recommended ratio is placed at 20:1. Following this reasoning, with 12 parameters of HSI to estimate, this study would require a minimum of 240 cases. Despite these recommendations, it remains more challenging to specify a reasonable absolute minimum sample size. Nevertheless, it helps to consider common sample sizes in SEM studies (Kline 2016). Xiong, Skitmore & Xia (2015) review of construction studies that applied SEM suggests that 31% of the included articles had less than 100 samples, while 77.4% had a sample size less than 200. A review of safety behaviour studies within the construction industry further reveals that a majority (76%) of the studies involving questionnaire surveys used sample sizes greater than 100 (Boateng, Davis & Pillay 2019). Based on these discussions, and heuristics such as the *N:q* rule, 350 participants would be expected to further avoid validity and reliability issues such as fit and chi-square problems.

In the case of VB-SEM, the minimum sample size should be the larger of (1) ten times the most number of formative indicators used to measure one construct, or (2) ten times the most number of structural paths directed at a specific latent construct (Hair, Ringle & Sarstedt 2011). Though there are formative constructs, there are no formative indicators in the structural model; hence, the largest number of structural paths, as shown in Figure 2.3, is two. A minimum sample of 20 is thus needed for the Partial Least

Squares-SEM (PLS-SEM). As such, the 350 participants are sufficient for both the PLS-SEM and the CB-SEM.

3.7 Sampling Technique

Sampling refers to the mechanism whereby a group of cases are drawn from a larger group (Walliman 2011). There are two fundamental sampling procedures: probability and non-probability (Walliman 2011). However, without accurate details of the current population, the representativeness of any sample is uncertain (Fellows & Liu 2015). Following Zhang, Lingard & Nevin (2015) and Newaz et al. (2019a) procedure, all participants were invited to voluntarily complete a survey. Further, the construction sites were chosen on the grounds of their readiness to partake in the study (Zhang, Lingard & Nevin 2015). Projects ongoing on these construction sites included high school developments, construction of new hospitals and a university campus. All the projects were in their executing stages, where workers are expected to have multiple social and physical interactions. This phase of construction allowed the workers to know each other and hence have a shared view about safety. Hence, the non-probability technique was used in reaching the organisations for data collection.

3.8 Questionnaire Sources and Measures

Questionnaires can be in an open or closed form. Considering the philosophical stance (postpositivism) and research design (quantitative), a closed-form questionnaire was used. This format provides a question and possible answers to participants to opt for as a suitable answer (Walliman 2011). Closed-form questionnaires are cheap and quick to administer, as well as easy to code (Walliman 2011). The instrument used in this study comprised four sections: (1) background of the respondent, (2) measuring safety climate, (3) human safety intervention practices, and (4) measuring safety performance.

In measuring safety climate this study adapted the questionnaire instrument by Mohamed (2002) which was comprised of 10 dimensions ("commitment", "communication", "safety rules and procedures", "supportive environment", "supervisory environment", "workers' involvement", "personal appreciation of risk", "appraisal of work hazards", "work pressure", and "competence") with seven items under each. These were assessed against a 5-point Likert scale, from "1=strongly disagree" to "5=strongly agree". Human safety interventions were assessed using the 11-item tool developed by Zaira & Hadikusumo (2017). These were "safety policy", "safety objectives", "safety organisation", "safety standard", "management worker interaction", "safety records", "incident and accident, analysis, and prevention", "in-house safety rules and regulations", "contracting strategy", "safety information management and feedback", "safety audit on overall safety management system", and "reviewing and implementing safety programmes". These were evaluated using a 5-point Likert scale from "1=strongly disagree" to "5=strongly agree".

To measure safety performance/behaviour, the safety compliance and participation constructs of Neal & Griffin (2006) were used, constituting three items per construct. These were assessed using a 5-point Likert scale from "1=strongly disagree" to "5=strongly agree". Hon, Chan & Yam (2014) three-item construct of "number of accident/injuries and near misses" was also used to evaluate safety outcomes. These were rated using a 5-point Likert scale, where "1=never" to "5=over eight times". Apart from the human safety interventions survey tool, all others have been extensively used, hence echoing the need to validate Zaira & Hadikusumo (2017) instrument. In this research, these questionnaires were piloted before main data collection by a small group of respondents (Fellows & Liu 2015) comprising construction and safety academics who have considerable industry knowledge.

3.9 Data Collection

This study followed the data collection approach by Newaz et al. (2019a, 2019b); Zhang, Lingard & Nevin (2015). Questions were displayed onscreen and the participants responded by clicking on their answers using an Audience Response System (ARS). This system uses an electronic handheld keypad that permits respondents to reply anonymously to multiple-choice questions posed by the researcher (Levy, Yardley & Zeckhauser 2017). With this approach, the participants' privacy and confidentiality are maintained (McCarter & Caza 2009). Using the ARS, Zhang, Lingard & Nevin (2015) amassed 356 valid responses among construction workers in New Zealand. Likewise, Newaz et al. (2019a) acquired 352 completed responses from construction sites in Australia. The participants would be given a clicker, which is the handheld device or keypad. The student researcher’s laptop acts as the receiver via an infrared/radio frequency/Bluetooth/WIFI technology. The respondents do not have to risk losing a response, since their answers are instantly saved on the researcher’s laptop.

3.10 Ethical Consideration

Working with human participants in your research always raises ethical issues about how you treat them (Walliman 2011, p. 42). According to Fellows & Liu (2015), the real traits of an ethical approach are culturally bound. Research ethics suggest moral principles that guide research from its genesis to accomplishment and beyond. In Australia, ethics committees in various institutions oversee the research performed concerning ethical matters. For this study, ethical considerations were adhered to before data collection. In this respect, the following criteria were regarded:

- Participants have the right to withdraw partially or completely and do not have to give a reason for the withdrawal, as well as having no penalty or disadvantages.

- Participation was voluntary with no coercion.
- Confidentiality of information and anonymity of respondents were assured.
- Effects on participants were considered, to avoid stress, embarrassment, discomfort, and pain.

This research project, including the questionnaire instrument and associated documents, was assessed, and approved by the University of Newcastle Human Research Ethics Committee (HREC) before any data collection was conducted (HREC Approval Number: H-2018-0462).

3.11 Data Analysis

This section presents information on how the collected data were treated to ensure its reliability. Afterwards, the section provides information on the kind of analyses and associated software that were applied to the treated data. Reasons were also provided for selecting specific types of analyses for addressing each research objective.

3.11.1 Data treatment

Data screening was performed to improve the quality and trustworthiness of data before analysis (DeSimone & Harms 2018). Both direct and statistical screening methods were employed to detect low-quality response patterns (DeSimone, Harms & DeSimone 2015) on the collected 317 cases. Missing data imputation is essential in SEM analysis (Ullman & Bentler 2012). This is particularly because dependence on complete cases usually results in an insufficient number of complete cases for model estimation and possibly biased estimated parameters (Ullman & Bentler 2012). For this study, missing data below the 5% criterion (Schafer 1999) were replaced using the multivariate imputation by chained equations (MICE) technique (Buuren & Groothuis-Oudshoorn 2010). The advantage of multiple imputation approaches is that it restores the natural variability of missing data and produces a valid statistical inference by accounting for the uncertainty associated with the estimation of missing values (Kang 2013). As a result, MICE has become known as a robust and principled approach for handling missing data (Kang 2013). After the exercise, 297 valid cases were arrived at for further analysis. To prevent response bias (Nunnally 1978), the safety climate instrument had some reversed questions. Some of these items include "Management only acts after incidents have occurred", "Current safety rules and procedures are so complicated that my co-workers do not pay much attention to them", "I believe that it is only a matter of time before my co-workers are involved in an accident" and "My co-workers believe some rules and policies are not practical". Prior to analysis, such questions were reverse coded/negated to reflect the true polarity of the construct being measured and/or relative to other items measuring the same construct (DiStefano & Motl 2006; Weijters & Baumgartner 2012).

3.11.2 Statistical analysis

Data analyses were performed using SmartPLS 3 (Ringle, Wende & Becker 2015), IBM SPSS Statistics 24, and AMOS 25 software. PLS-SEM was employed to address Objectives Three and Four because it is the appropriate method when (1) the goal is theory development, (2) formative constructs exist in the structural model, (3) the structural model is complex, or (4) latent variable scores would be used in subsequent analyses (Hair, Ringle & Sarstedt 2011). Also, the confirmatory factor analysis (CFA) from the CB-SEM was used to address Objective Five, considering its ability to confirm the proposed factor structures by exploratory factor analysis (EFA). Therefore, the CFA was used to refine and validate the developed scale (Xiong, Skitmore & Xia 2015).

SEM is thought of as a fusion between factor analysis and path analysis (Ozorhon et al. 2008; Weston & Gore Jr 2006). SEM is a statistical procedure for testing measurement and practical, predictive, and causal assumptions (Bagozzi & Yi 2012). It has a family of statistical tools that allow researchers to easily examine multivariate models (Martens & Haase 2006; Weston & Gore Jr 2006; Worthington & Whittaker 2006). The SEM approach addresses the problem of multiple errors and hence it has a superior capacity to estimate and test the association among constructs (Weston & Gore Jr 2006). As such, SEM can be used to test links between latent and manifest variables (Xiong, Skitmore & Xia 2015). Considering the variety of models in this study: mediation, moderation, and direct – SEM is an obvious choice because of its ability analyse a greater range of latent variable models (Kline 2016). Owing to these advantages, Boateng, Davis & Pillay (2019) review of safety behaviour studies within the construction industry identified that 42% of the articles that adopted inferential statistics (74%) employed SEM.

The SEM procedure consists of two components: measurement and structural model. The measurement model, using CFA, allows researchers to formalise their measurement prepositions and develop measurement instruments (Asparouhov & Muthén 2009) because CFA validates the suitability of a measurement model before developing the structural model. In effect, CFA permits researchers to examine how adequate measured variables fuse to determine the underlying structures of hypothesised constructs (Weston & Gore Jr 2006). CFA is therefore used in validating the human safety intervention survey instrument in this study. Researchers (e.g. Newaz et al. 2019c; Zahoor et al. 2017) have employed the CFA to validate safety-related survey instruments. The structural model denotes the part of the model that defines the assumed association among latent variables (Weston & Gore Jr 2006). In other words, the structural model specifies the paths of the hypothesised relationships among the dependent and independent variables.

The maximum likelihood estimation (MLE) approach was adopted, since it can analyse models with a considerable number of latent variables (Kline 2016). Also, various indexes are available to assess the fit of a SEM. These indexes are assessed once the model has been estimated (Weston & Gore Jr 2006). They could be grouped into the absolute fit, incremental fit, parsimony-adjusted, and predictive fit indexes (Kline 2016).

3.12 Chapter Summary

This chapter described the research methodology for the thesis. The research adopts the postpositivist stance as it tests the relationships among climate constructs, HSIs, safety behaviour and safety outcomes using the quantitative research approach. Data were collected from five construction sites by applying a cross-sectional survey strategy. Participants for the study were construction trade workers over the age of 18 years. A sample size of 350 was deemed sufficient to cater to the inferential needs of the structural equation modelling techniques. The non-probability sampling technique was used in reaching the employers of the construction workers. Sources of the questionnaire instruments for measuring each construct were also identified. The audience response system was used to answer the questions from the instruments displayed on the screen. All these processes adhered to the ethical considerations concerning human participants. The collected data were cleaned to ensure valid and quality data. Finally, the PLS-SEM, EFA, and CFA were used to analyse the data. The analysis and results for the research objectives are detailed in the next chapter.

4 DATA ANALYSES AND RESULTS

4.1 Introduction

This chapter presents the analyses and results related to Objectives Three, Four, and Five. Initially, the demographic characteristics of the valid sample are described. Next, the human safety intervention (HSI) scale is developed and validated. Afterwards, empirical evidence is provided on the role of HSI in influencing the relationship between workgroup safety climate and co-workers safety outcomes. Finally, how co-worker safety outcomes predict workgroup safety climate perceptions are examined.

4.2 Socio-Demographic Profile of Respondents

In terms of gender, 77.1% were males, 0% were females, and 22.9% selected the "not applicable" option. Among the nineteen listed trades, 21.5% of the valid sample were labourers, 20.2% were plant/equipment operators, 18.2% were carpenters/form workers, 16.2% were electrical and mechanical workers, 7.7% were plumbers, 6.1% were scaffolders, and 4% were roofers. Metalworkers, welders/boilermakers, and dogmen each constituted 2%. There were no participants from the remaining nine listed trades. Thirty per cent of the respondents had less than five years of experience in the construction industry, 26.3% had between 5 and 10 years, 6.1% had between 11 and 15 years, 8.4% had between 16 and 20 years, and 29.3% had more than 20 years of experience. Respondents were also asked about their length of service with their current organisation. The majority (62%) had been with their organisation less than 5 years, 29.3% had been with their organisation more than 20 years, 14.8% had been with their organisation from 5 to 10 years, 8.1% had been with their organisation from 11 to 15 years, and 2.7% worked with their organisation from 16 to 20 years. Concerning their employer, 68.7% of the workers were employed by the subcontractor and 31.3% were employed by the head contractor. Also, a majority (64.3%) of the respondents were full-time workers and the remaining 35.7% were part-time workers. The full details and characteristics of respondents are provided in Table 4.1.

Table 4. 1: Profile of respondents (N=297)

Demographic variable	Group/category	Frequency	(%)
Gender	Male	229	77.1
	Female	0	0
	Not applicable	68	22.9
Trade	Labourer	64	21.5
	Electrical and mechanical worker	48	16.2
	Roofer	12	4
	Metalworker	6	2
	Welder/boilermaker	6	2
	Carpenter/form worker	54	18.2
	Plumber	23	7.7
	Scaffolder	18	6.1
	Dogman	6	2
	Plant/equipment operator	60	20.2
Work experience in the industry	Less than 5 years	89	30
	5-10 years	78	26.3
	11-15 years	18	6.1
	16-20 years	25	8.4
	More than 20 years	87	29.3
Length of service with current organisation	Less than 5 years	184	62
	5-10 years	44	14.8
	11-15 years	24	8.1
	16-20 years	8	2.7
	More than 20 years	37	12.5
Employed by	Head contractor	93	31.3
	Subcontractor	204	68.7
Employment type	Full-time	191	64.3
	Part-time	106	35.7

4.3 Descriptive and Reliability Analyses

Before building the CB-SEM model, it is essential to examine the features of the data (Xiong, Skitmore & Xia 2015). Both EFA and CFA assume a normal distribution. Satisfying this assumption is important because the means and covariance matrix would represent all the information (Hox 1998). Violating the assumption can also underestimate the standard errors and inflate the goodness-of-fit indexes (MacCallum, Roznowski & Necowitz 1992). Further, when the data is normally distributed, the solution is enhanced (Tabachnick & Fidell 2014). For the normality test, the ±2.2 guideline for skewness and kurtosis (Sposito, Hand & Skarpness 1983) was employed. In Table 4.2, skewness coefficients of all items ranged between -0.306 to 0.679, and -1.752 to -0.498 for kurtosis, suggesting a normally distributed data.

The correlative adequacy among the items was checked to avoid multicollinearity issues. High multicollinearity in SEM can lead to inaccurate estimates for both coefficients and standard errors, hence increasing the probability of Type II errors (Grewal, Cote & Baumgartner 2004). Bivariate correlations higher than 0.85 signal potential problems (Kline 2005). In Table 4.2, all correlations are below the 0.85 threshold.

The Cronbach's alpha was used to measure the internal consistency among items in the instrument to assess its reliability (Santos 1999). Usually, Cronbach's alpha coefficient ranges between 0 and 1 (Cronbach 1951). A reliability coefficient ">0.9 is Excellent, >0.8 is Good, >0.7 is Acceptable, >0.6 is Questionable, >0.5 is Poor, and <0.5 is Unacceptable" (George & Mallery 2003, p. 231). Nevertheless, Cronbach's alpha of 0.8 is a reasonable goal (Gliem & Gliem 2003). In Table 4.3, Cronbach's alpha if item deleted ranged from 0.876 to 0.885, while the overall coefficient was 0.889, implying that responses are consistent (Kline 2016). Hence, all items remained intact.

Table 4. 2: Descriptive statistics and correlations among variables

Factor	Mean	SD	Skewness	Kurtosis	HSI_1	HSI_2	HSI_3	HSI_4	HSI_5	HSI_6	HSI_7	HSI_8	HSI_9	HSI_10	HSI_11	HSI_12
HSI_1	4.38	0.485	0.51	-1.752	1											
HSI_2	4.34	0.475	0.679	-1.55	.556**	1										
HSI_3	4.45	0.512	0.045	-1.634	.618**	.604**	1									
HSI_4	4.36	0.541	-0.019	-0.89	.466**	.451**	.686**	1								
HSI_5	4.3	0.502	0.37	-0.781	.541**	.459**	.596**	.674**	1							
HSI_6	4.26	0.59	-0.138	-0.506	.318**	.263**	.305**	.370**	.315**	1						
HSI_7	4.29	0.574	-0.111	-0.558	0.087	.142*	.204**	.363**	.242**	.633**	1					
HSI_8	4.38	0.558	-0.176	-0.835	.299**	.284**	.444**	.353**	.343**	.528**	.544**	1				
HSI_9	4.43	0.51	0.112	-1.618	.319**	.309**	.437**	.356**	.368**	.444**	.372**	.528**	1			
HSI_10	4.44	0.549	-0.27	-0.988	.345**	.442**	.378**	.386**	.306**	.467**	.432**	.466**	.575**	1		
HSI_11	4.28	0.568	-0.06	-0.498	.222**	.353**	.337**	.310**	.393**	.562**	.456**	.603**	.460**	.429**	1	
HSI_12	4.43	0.56	-0.306	-0.874	.282**	.197**	.274**	.228**	.267**	.407**	.342**	.420**	.478**	.386**	.432**	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 4. 3: Reliability analysis

Cronbach's Alpha	0.889
Factor	Cronbach's Alpha if Item Deleted
HSI_1	0.883
HSI_2	0.883
HSI_3	0.877
HSI_4	0.878
HSI_5	0.879
HSI_6	0.877
HSI_7	0.884
HSI_8	0.876
HSI_9	0.878
HSI_10	0.878
HSI_11	0.878
HSI_12	0.885

4.4 Exploratory Factor Analysis

EFA was performed using maximum likelihood as the extraction method with Promax (Hendrickson & White 1964) rotation to identify the underlying structures among the observed variables. The study employed maximum likelihood because it is the best extraction method (DeCoster 1998), and produces the most precise estimates when dealing with normally distributed data (Ullman & Bentler 2012). In addition, maximum likelihood is the most robust technique to use when the data is moderately non-normal (Anderson & Gerbing 1984; Weston & Gore Jr 2006). Due to such advantages, maximum likelihood is commonly used for the estimation procedure in SEM (Anderson & Gerbing 1984; Bagozzi & Yi 2012). As maximum likelihood would be adopted at the SEM/CFA level, implementing it for the EFA procedure further ensures consistency in estimates.

To make factors more meaningful, they are rotated after extraction (Netemeyer, Bearden & Sharma 2003). When the objective of the EFA is for scale development, the Promax method is often recommended. Promax rotation permits correlated factors and is the most extensively used oblique rotation technique (DeCoster 1998; Kline 2016), and often appropriate for social science research (Beavers et al. 2013). On the other hand, whereas numerous researchers reported using orthogonal approaches, a critical review by Ford, MacCallum & Tait (1986) suggested that oblique methods such as Promax are superior to orthogonal rotations (Conway & Huffcutt 2003). According to the review, “choices made by researchers have generally been poor…concerning factor model, retention criteria, rotation, interpretation of factors and other issues relevant to factor analysis” (Ford, MacCallum & Tait 1986, p. 291). Therefore, the maximum likelihood extraction method with Promax rotation yields higher generalisability and replicability power (Tabachnick & Fidell 2001a).

4.4.1 Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity

The KMO is a ratio of the sum of squared correlations to the sum of squared correlations plus the sum of squared partial correlations (Kaiser 1970). It measures the shared variance in the items (Beavers et al. 2013). Kaiser & Rice (1974) provided the following guidelines for assessing the KMO: in the 0.90s is acceptable, in the 0.80s is meritorious, in the 0.70s is middling, in the 0.60s is mediocre, in the 0.50s is miserable, and below 0.50 is unacceptable. Against this background, the KMO measure of 0.853 sample adequacy in this study (Table 4.4) indicates that the number of responses was meritorious for model assessment (Kaiser & Rice 1974).

The Bartlett’s Test of Sphericity compares the correlation matrix to an identity matrix. When the correlation matrix is not an identity matrix, the test should be significant, hence suitable for EFA (Hair et al. 1995; Netemeyer, Bearden & Sharma 2003; Tabachnick & Fidell 2001b). The test is likely to be significant with substantial size samples; hence, it is recommended when there are few samples per variable (Tabachnick & Fidell 2014). Nonetheless, in this study (Table 4.4), the test was significant (p = 0.000).

Table 4. 4: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.853
Bartlett's Test of Sphericity	Approx. Chi-Square	1757.855
	df	66
	Sig.	.000

4.4.2 Communalities

Communalities are the sum of squared loadings for variables across factors (Tabachnick & Fidell 2014). In general, we often prefer to have uniformly high correlations (Costello & Osborne 2005), that is, above 0.8 or greater (Velicer & Fava 1998). Nevertheless, this is unlikely to occur in real data (Costello & Osborne 2005; Mulaik 1990; Widaman 1993). In the behavioural or social sciences, communalities from 0.30 to 0.70 are often popular (Costello & Osborne 2005; de Winter, Dodou & Wieringa 2009; Lingard & Rowlinson 2006). Given this background, and considering the large sample used in this study, and that all communalities are above 0.3, it is suggested that the sample size is adequate for EFA (de Winter, Dodou & Wieringa 2009; Henson & Roberts 2006). Hence, the factor structure and individual items were valid for further analysis (Costello & Osborne 2005).

Table 4. 5: Communalities

Factor	Initial	Extraction
HSI_1	.528	.514
HSI_2	.495	.468
HSI_3	.671	.760
HSI_4	.630	.579
HSI_5	.563	.536
HSI_6	.554	.586
HSI_7	.536	.544
HSI_8	.551	.572
HSI_9	.489	.451
HSI_10	.483	.434
HSI_11	.526	.517
HSI_12	.326	.315

Extraction Method: Maximum Likelihood.

4.4.3 Factor extraction model

It is recommended that multiple techniques in factor extraction are adopted. In reality, according to Netemeyer, Bearden & Sharma (2003, p. 8), “no single rule of thumb or psychometric criterion should be relied upon in deciding the number of factors to extract”. The eigenvalues, scree plot, and the percentage of variance explained serve as guides in determining the number of factors for representing the 12 items.

Each eigenvalue corresponds to a different potential factor (Tabachnick & Fidell 2014). The eigenvalue, therefore, indicates the amount of variance accounted for by a factor. Usually, only large eigenvalues are kept since they explain the most variance. According to Kaiser’s criterion, all factors that are above or equal to the eigenvalue of 1 are retained (Costello & Osborne 2005; Kaiser 1960). Hence, items with low variance could be combined under a factor accounting for more variance (Beavers et al. 2013). A factor must at least account for as much variance as explained by an individual item (Netemeyer, Bearden & Sharma 2003). In Table 4.6, two factors had their eigenvalues greater than 1 and hence account for the majority of variance in the data. However, the Kaiser criterion has often received some criticisms, such as inaccurate estimation of factor retention (Costello & Osborne 2005; Fabrigar et al. 1999; Henson & Roberts 2006; Velicer & Jackson 1990).

In terms of the cumulative percentage of variance criterion, no fixed threshold exists; however, some percentages have been proposed (Williams, Onsman & Brown 2010). For the natural sciences, at least 95% should be explained, while as low as 50-60% is common in the humanities, and for any factor to be significant, at least 5% of the total variance should be ascribed to that factor (Hair et al. 1995). In Table 4.6, it can be observed that the two factors suggested by the eigenvalue heuristic also explained more than the 5% of the "total variance criterion". The cumulative percentage of the variance of those two factors also accounts for 59.927%.

The scree test heuristic (Cattell 1966) provides further insights into the optimal number of factors. With this test, the graphed eigenvalues for breaks in the plot were examined (Hayton, Allen & Scarpello 2004). At the breaking point, factors that do not belong to the scree are retained (Cattell & Jaspers 1967). The scree plot is only reliable when the sample is 200 or more (Yong & Pearce 2013). Following this view, with 297 samples, the scree test is appropriate for this study. However, the scree test method suffers from ambiguity when there are no clear breaks, or two or more obvious discontinuities (Hayton, Allen & Scarpello 2004). Fortunately, the scree plot in Figure 4.1 suggests two factors, implying that, after the second factor, there is insignificant information gain, and hence additional factors do not significantly improve the model (Ampofo & Boateng 2020). As such those factors beyond the elbow merely represent unique factors (Netemeyer, Bearden & Sharma 2003).

Table 4. 6: Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5.438	45.316	45.316	4.941	41.177	41.177	4.253
2	1.753	14.612	59.927	1.334	11.113	52.29	4.073
3	0.856	7.136	67.064				
4	0.694	5.781	72.844				
5	0.632	5.267	78.111				
6	0.585	4.872	82.984				
7	0.496	4.135	87.119				
8	0.439	3.662	90.781				
9	0.36	2.999	93.78				
10	0.316	2.631	96.411				
11	0.233	1.945	98.356				
12	0.197	1.644	100				

Extraction Method: Maximum Likelihood.

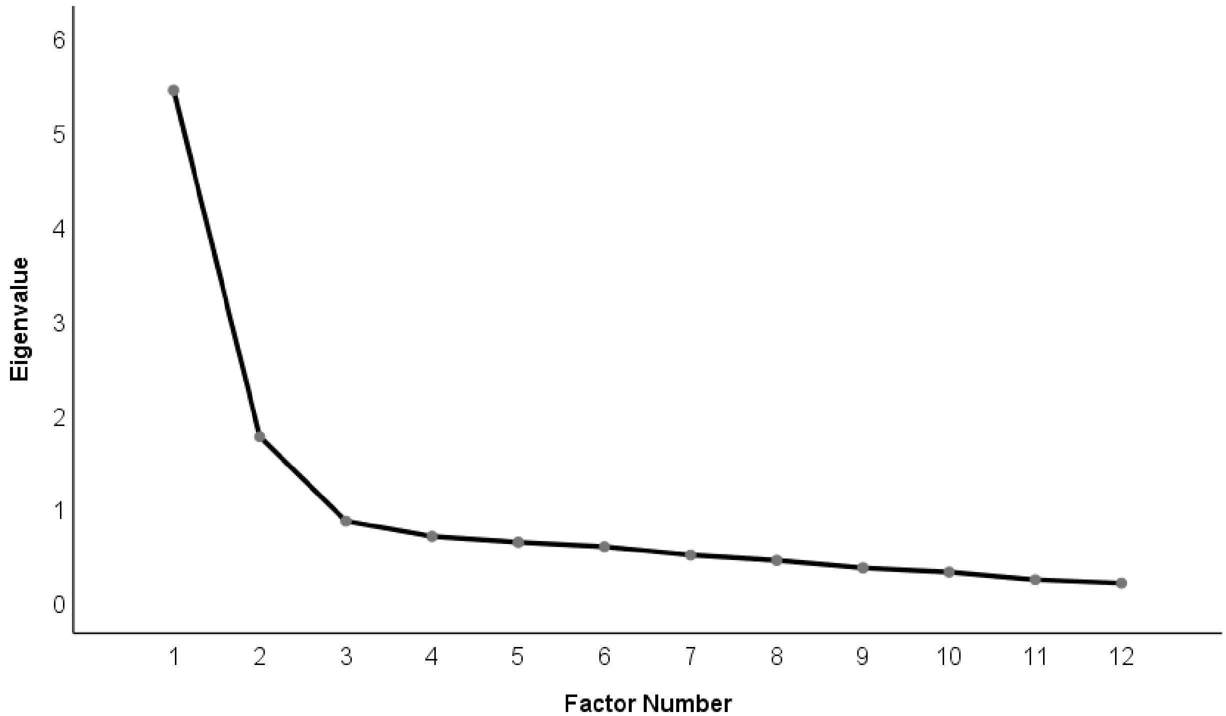

Figure 4. 1: Scree plot

4.4.4 Factor loadings

Factor loadings from the EFA are observed and used to trim the number of items during the development of the scale before the CFA (Netemeyer, Bearden & Sharma 2003). These loadings indicate how much the item contributes to a factor; the higher the loading on a factor, the more the item has contributed to that factor (Harman 1976; Yong & Pearce 2013). Decision rules for retaining items that significantly load on a factor is, to some extent, open to debate (Floyd & Widaman 1995). However, factor loadings greater than 0.50 have been suggested as very significant (Hair et al. 1995; Lastovicka et al. 1999). In Table 4.7, it can be observed that all loadings were greater than the 0.50 rule of thumb. This suggests that the 12 items account for at least 50% of the relationships within the data, and hence are significant to their corresponding factor.

Also, there were no high cross-loadings on a factor, other than the intended factor. There is a cross-loading when an item has a loading of 0.32 or higher on two or more factors (Costello & Osborne 2005; Tabachnick & Fidell 2001b). When cross-loadings persist after numerous solutions, it indicates that there is a problem with how the item was constructed, scale design, or the data itself (Costello & Osborne 2005).

Table 4. 7: Pattern Matrix

Factor	Items	HSI1	HSI2
HSI_1	My co-workers are provided with adequate safety training for their job	-0.071	0.754
HSI_2	Toolbox meetings are frequently organised for my co-workers to attend	-0.010	0.690
HSI_3	My new co-workers are given safety inductions before commencing work	-0.039	0.893
HSI_4	My co-workers are encouraged to get involved in safety campaigns	0.086	0.709
HSI_5	My co-workers are always involved in job hazard analysis for specific tasks	0.055	0.700
HSI_6	My co-workers have easy access to safety information	0.791	-0.047
HSI_7	My co-workers are given adequate safety supervision on site	0.831	-0.199
HSI_8	My co-workers are provided with safety awareness programs	0.711	0.076
HSI_9	My co-workers are provided with workplace programs designed to influence their actions toward maintaining safe workplace	0.546	0.190
HSI_10	My co-workers are offered safety incentives (e.g., safety awards) for working safely	0.540	0.181
HSI_11	My co-workers have easy access to safety bulletin boards	0.704	0.026
HSI_12	My co-workers have the requisite safety certification for undertaking high-risk activities	0.540	0.036

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.

Using a factor plot, rotation in EFA aligns clusters of items plotted in a dimensional space with the axis lines (Osborne 2015). This further clarifies the loading patterns provided in Table 4.7 (Osborne 2015). Figure 4.2 is a factor plot that shows the two factors and the associated items plotted as a function of the factors. The factor plot is relevant for interpretation when there are at most two factors (Yong & Pearce 2013). As observed in the factor plot, there are clear separations between the two factors and hence strong support for the two-factor solution.

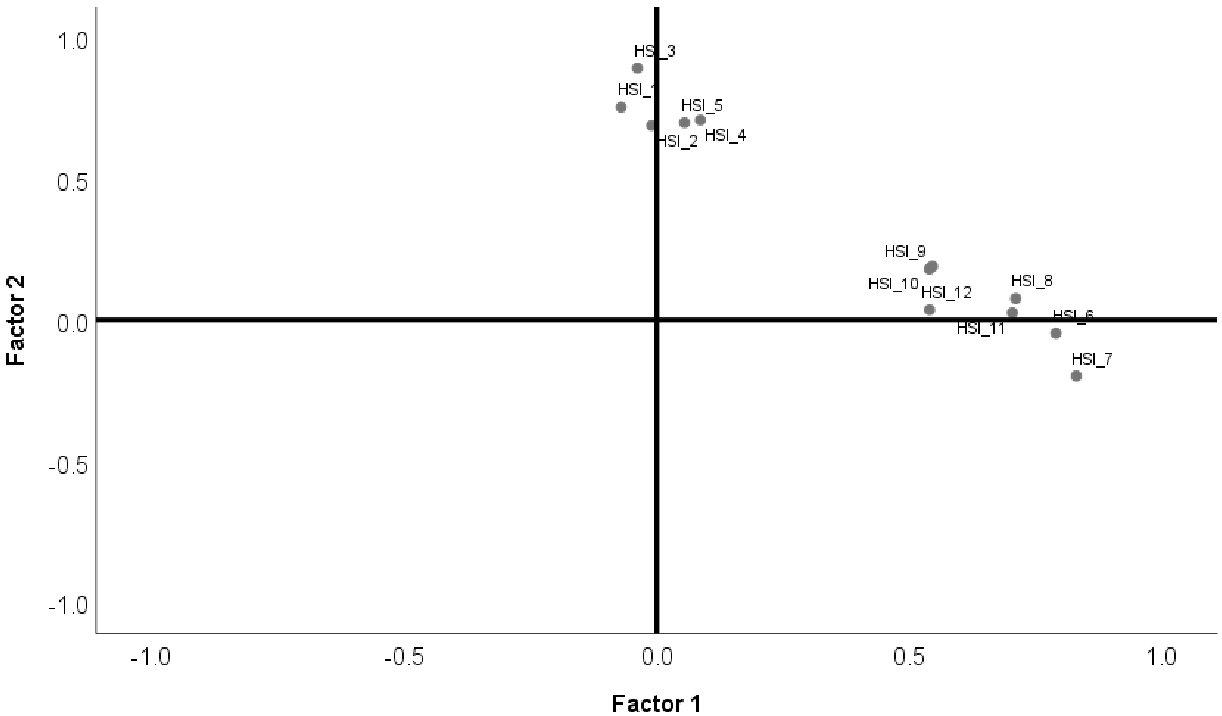

Figure 4. 2: Factor plot in rotated factor space

4.4.5 Factor correlation matrix

When the rotation is oblique, as used in this study, other matrices such as the factor correlation matrix, are produced (Tabachnick & Fidell 2007). The factor correlation matrix reveals the correlations between the factors (Costello & Osborne 2005; Yong & Pearce 2013). In Table 4.8, the factor correlation matrix yielded a coefficient of 0.561, which is less than the 0.85 threshold (Kline 2005); hence, the two factors are not highly correlated. Also, when the correlations in the factor correlation matrix exceed 0.32, there is at least 10% overlap in the variance among factors, hence further confirming the use of oblique rotation (Tabachnick & Fidell 2007). Considering the 0.561 in this study, there is more than 10% overlap in the variance among the extracted factors. Hence, an interplay is expected among the factors to mutually explain each other. This suggests that the two factors can be regarded as reflective-

reflective constructs. With such factors, there is a possibility of item substitution, good positive correlation, similar indicator antecedents and consequences, and a unidimensional nature (Bollen & Lennox 1991; Jarvis, MacKenzie & Podsakoff 2003).

Table 4. 8: Factor Correlation Matrix

Factor	1	2
1	1	0.561
2	0.561	1

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalisation.

4.5 Confirmatory Factor Analysis

CFA is a form of SEM that deals with measurement models. The CFA was used to confirm the two-factor model hypothesised by the EFA, and whether it does or does not fit the data, suggesting that the number of factors and its structure are specified a priori in CFA (Netemeyer, Bearden & Sharma 2003). The relevance of CFA to scale development is that it evaluates the internal consistency and validity of a measure (Netemeyer, Bearden & Sharma 2003). CFA primarily employs the maximum likelihood estimation (MLE) approach, which aligns with the EFA estimation approach used in this study. CFA is an essential statistical tool for construct validation (Brown 2015). Construct validity is examined to measure the "extent to which indicators of a construct measure what they are purported to measure" (Bagozzi & Yi 2012, p. 18). It provides evidence of both convergent and discriminant evidence of theoretical constructs. These tests are important for assessing scale reliability. CFA is therefore an indispensable analytic technique for psychometric evaluation (Brown 2015).

4.5.1 Convergent and discriminant validity of the initial measurement model

Convergent validity deals with whether or not a group of items share a high amount of common variance (Thornton, Henneberg & Naudé 2014). Put simply, how well the corresponding items of a factor represent that factor. Hair et al. (1995) recommend that for acceptable convergent validity: (1) factor loadings should be greater than 0.5, (2) average variance extracted (AVE) should be at least 0.5, and (3) composite reliability (CR) should be above 0.7. In Figure 4.3, all standardised factor loadings are above 0.5, ranging from 0.67 to 0.86 for HSI2 and 0.58 to 0.77 for HSI1. Also, while the AVE for HSI2 is greater than 0.5, the AVE for HSI1 is 0.478, suggesting that some of the variables in HSI1 do not correlate well, hence the need to improve the model.

On the other hand, discriminant validity evaluates how a factor is uniquely different from others. Thus, discriminant validity is confirmed when the items of these theoretically distinct factors are not highly intercorrelated (Brown 2015). As such, an ideal level of divergence is expected among the two factors to imply evidence of discriminant validity. The Fornell-Larcker criterion and the Heterotrait-Monotrait ratio (HTMT) are applied to assess the discriminant validity (Henseler, Ringle & Sarstedt 2015). According to the Fornell-Larcker criterion, the AVE of a construct should be higher than its largest squared correlation with other constructs (Fornell & Larcker 1981a). There are no discriminant validity issues, as observed in Table 4.9, since the AVEs are greater than the inter-factor correlations and the maximum shared variance (MSV) (Hair et al. 1995).

Nevertheless, the Fornell-Larcker criterion has often been criticised for its limitations, mainly because the criterion does not reliably identify the absence of discriminant validity (Henseler, Ringle & Sarstedt 2015). While this problem of the Fornell-Larcker criterion is often associated with variance-based SEM, a more robust method for assessing discriminant validity was required, since the goal in this study is to use the developed survey in further analysis, such as the PLS-SEM, which is variance-based. Henseler, Ringle & Sarstedt (2015) propose a superior alternative, HTMT, which has been found to effectively handle discriminant validity issues associated with the traditional assessment of discriminant validity methods. The HTMT should be below 0.85 to establish discriminant validity (Henseler, Ringle & Sarstedt 2015). However, there are no discriminant validity issues as the HTMT is 0.598 as observed in Table 4.9.

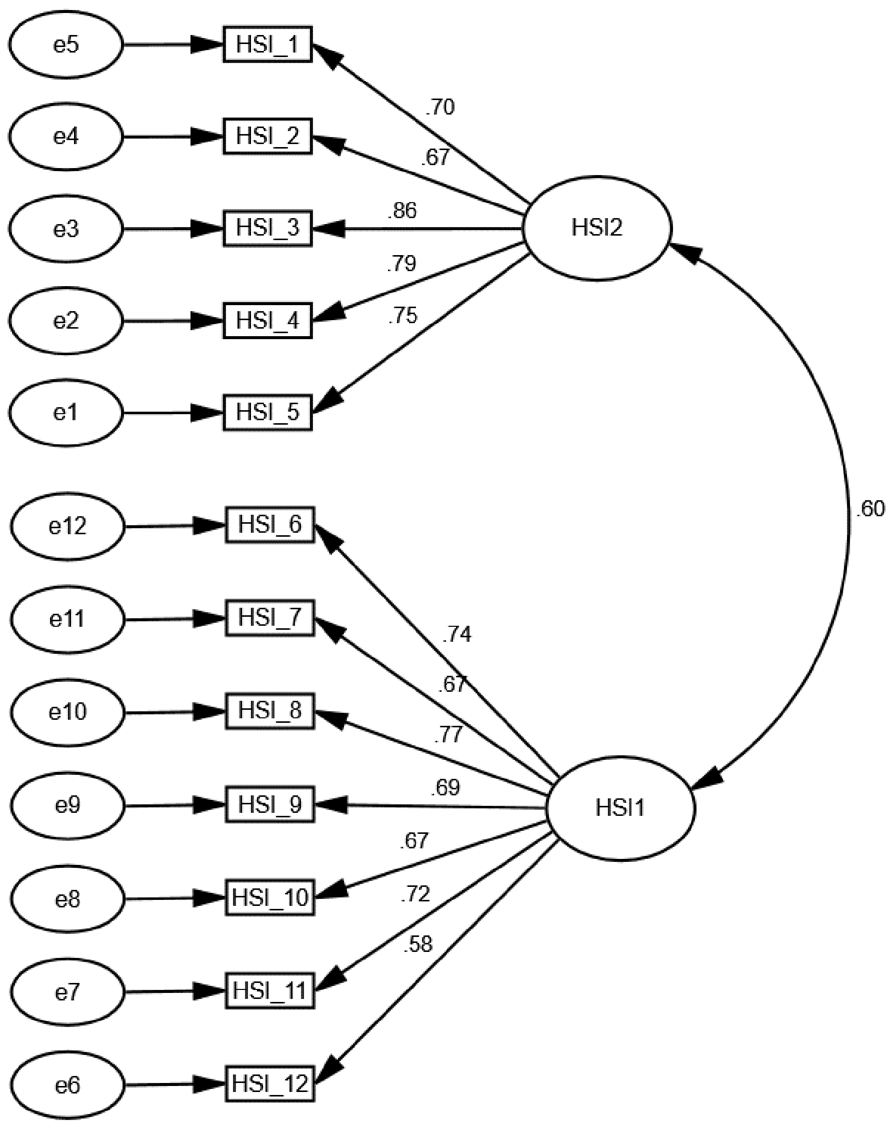

Figure 4. 3: Initial measurement model with factor loadings

Table 4. 9: Convergent and discriminant validity of factors of the initial model

Factors	CR	AVE	MSV	MaxR(H)	HSI2	HSI1	HTMT Analysis	
HSI2	0.868	0.570	0.356	0.881	0.755			HSI2
HSI1	0.864	0.478	0.356	0.870	0.596***	0.691	HSI1	0.598

*** p < 0.001, MaxR(H) = maximum reliability: (H)

4.5.2 Model fit of the initial model

Model fit examines how well the specified model explains the relationships between variables in our data. Goodness-of-fit indices are relevant for this study considering the use of a covariance matrix. These SEM model fit indices help to endorse the appropriate statistical power and accuracy of the parameter estimates in an SEM assessment. As such, model fit measures depend on how proximal the model-implied covariance matrix approximates the observed covariance matrix (Garson 2016).

Hu & Bentler (1999) recommend cut-off values for fit indices such as comparative fit index (CFI), standardised root mean squared residual (SRMR), root mean squared error of approximation (RMSEA) and *p* of close fit (PClose). The recommended thresholds for these metrics are shown in Table 4.10, accompanied by this study's estimates and corresponding interpretation. In the initial measurement model, the estimates of the CFI, RMSEA, and PClose indicate some disagreements between the proposed and estimated model.

Table 4. 10: Model fit measures of the initial model

Measure	Estimate	Recommended Threshold	Interpretation
CMIN	262.662	--	--
DF	53	--	--
CMIN/DF	4.956	Between 1 and 3	Acceptable
CFI	0.878	>0.95	Terrible
SRMR	0.064	<0.08	Excellent
RMSEA	0.116	<0.06	Terrible
PClose	0	>0.05	Not Estimated

4.5.3 Convergent and discriminant validity of the final measurement model

Further revisions were made to the initial measurement model to improve its construct validity and model fit. For instance, modification indices were iteratively examined while freeing up the parameter with the largest modification index (Henseler, Ringle & Sarstedt 2015). Standardised residual covariances were also observed for potential issues (Hair et al. 1995). HSI_1, HSI_2, HSI_7, HSI_8, HSI_11 and HSI_12 were eliminated iteratively while cross-examining factor loadings, path estimates, modification indices and standardised residuals. After the exercise, the final model attained good convergent and discriminant validity (Table 4.11). Also, standardised loadings were above 0.50, and the correlation between the two factors increased from 0.60 in the initial model to 0.62 in the final model, confirming the reflective-reflective nature of the hierarchical model.

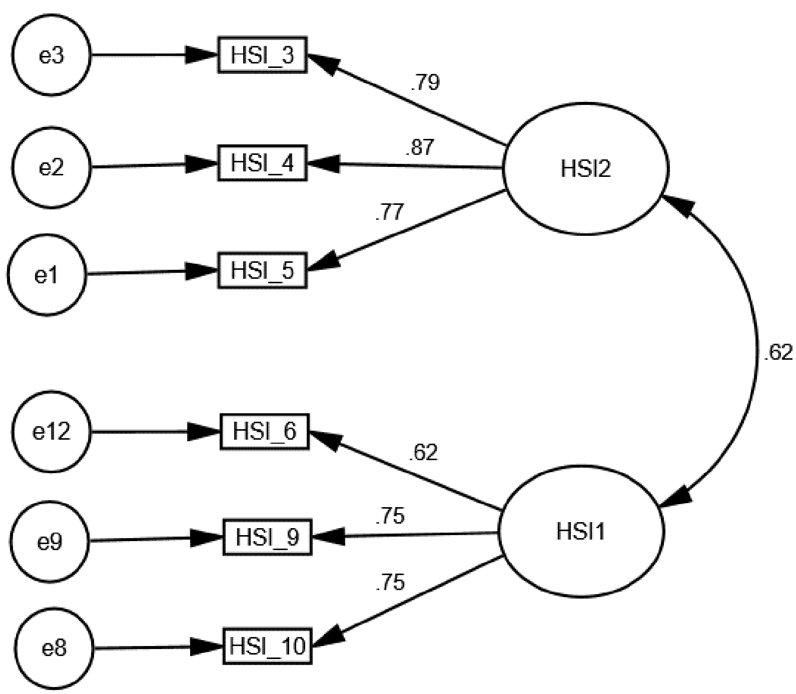

Figure 4. 4: Final measurement model with factor loadings

Table 4. 11: Convergent and discriminant validity of factors of the final model

Factors	CR	AVE	MSV	MaxR(H)	HSI2	HSI1	HTMT Analysis	
HSI2	0.851	0.656	0.379	0.860	0.810			HSI2
HSI1	0.751	0.504	0.379	0.763	0.616***	0.710	HSI1	0.630

*** $p < 0.001$, MaxR(H) = maximum reliability: (H)

4.5.4 Model fit of the final model

The final model attained good fit with three variables under each factor, suggestive of how well the final model fits the data (Table 4.12). The removal of the six items did not influence the integrity of the factors since the eliminated items were covered to a reasonable extent by other overlapping items. Thus, the stability of a factor was defined by the factor having at least three variables loading on it both substantively and distinctively (Arrindell et al. 1983; Hair et al. 1995; Walker 2010).

Table 4. 12: Model fit measures of the final model

Measure	Estimate	Recommended Threshold	Interpretation
CMIN	16.536	--	--
DF	8	--	--
CMIN/DF	2.067	Between 1 and 3	Excellent
CFI	0.987	>0.95	Excellent
SRMR	0.0249	<0.08	Excellent
RMSEA	0.06	<0.06	Acceptable
PClose	0.299	>0.05	Excellent

4.6 Partial Least Squares-Structural Equation Modelling

The increasing application of PLS-SEM has paved the way for researchers to shift from relatively small and focused models to more advanced model designs (Sharma et al. 2019), such as hierarchical component models (Ringle et al. 2020). The PLS-SEM provides an environment for investigators to model both lower-order and higher-order constructs (Lohmöller 2013; Sarstedt et al. 2019). When the path models have lower-order constructs that form the higher-order construct, then PLS-SEM is the ideal modelling approach (Hair, Sarstedt & Ringle 2019). Likewise, the capabilities of PLS-SEM in dealing with multiple mediating and moderating variables in an entire model structure makes it superior to regression analysis (Hair, Sarstedt & Ringle 2019). As in the case of this study, there are several types of higher-order components (e.g. CSB, HSI, and WSC) as well as lower-order components (e.g. MgtCommit, CurntRules, and MgtCommun). Also, two mediating and moderating effects are to be estimated, hence further confirming the use of PLS-SEM in this study. There are two stages of assessing PLS-SEM results: (1) assessment of measurement model and (2) assessment of structural model (Chin 2010; Sarstedt, Ringle & Hair 2017).

4.6.1 Specification of the initial measurement model

The measurement model in Figure 4.5 consists of five lower-order reflective constructs (i.e. MgtCommit, CurntRules, MgtCommun, SupvyEnv and AccNearMiss), one reflective-reflective higher-order construct (i.e. HSI), and two reflective-formative higher-order constructs (i.e. WSC and CSB). Such a multifaceted mixture of constructs, especially the inclusion of hierarchical components, can help to overcome the bandwidth-fidelity dilemma (Cronbach & Gleser 1957).

Several techniques have been proposed for specifying and estimating hierarchical models. The most renowned methods are the repeated indicators approach and the two-stage approach (Ringle, Sarstedt & Straub 2012). Through numerous simulations by Becker, Klein & Wetzels (2012), the repeated indicators approach yields minimal biases in the estimation of the associations between lower-order and higher-order constructs. Nevertheless, both techniques usually produce very similar conclusions when sample sizes are adequately large (Sarstedt et al. 2019). Considering these, the repeated indicators approach was applied in this study (Figure 4.5). This was done by assigning all indicators of the lower-order constructs to the higher-order constructs (Lohmöller 2013; Wold 1982). Of note, the repeated indicators on the higher-order constructs in Figure 4.5 are hidden (see "[+]" on HSI, WSC and CSB), since when these are shown the diagram becomes too messy.

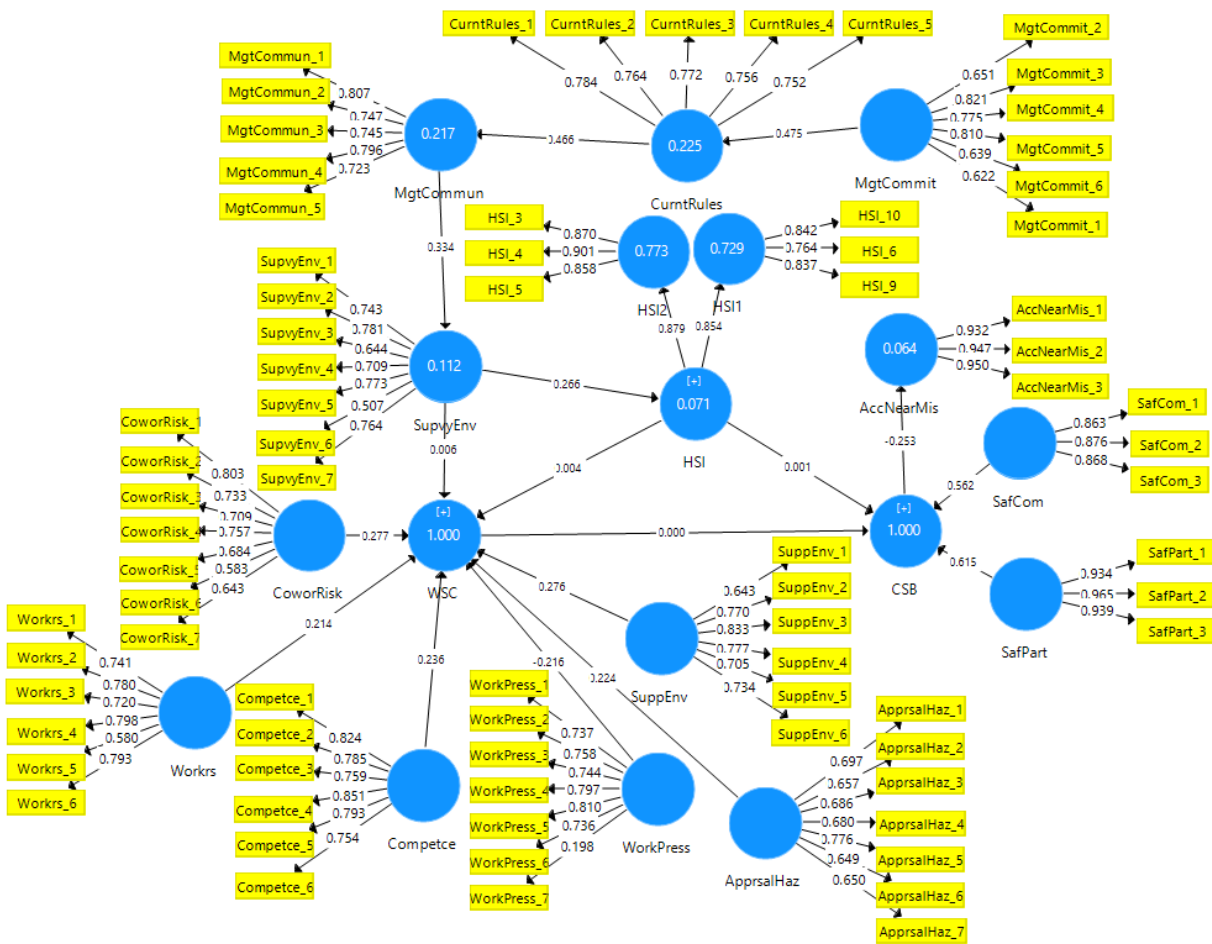

Figure 4 5: Initial measurement model

4.6.2 Evaluation of initial measurement model

First, the validity of the first-order and second-order constructs was assessed by examining the convergent and discriminant validity, as well as scale reliability. For this study, all first-order constructs were reflective. In the case of reflective indicators, loadings are expected to be more than the 0.4 threshold for samples greater than 200 (Hair et al. 2010). Further, for acceptable item reliability, a construct is expected to account for more than 50% of the item variance (Hair et al. 2019). Therefore, a 0.5 criterion was employed in this study. The pattern matrix (see Table 4.13) shows that WorkPress_7 was below the criterion. Three approaches were used to evaluate the internal consistency reliability: Cronbach's alpha (Cronbach 1951), composite reliability (CR) (Jöreskog 1971), and DiJkstra-Henseler's rho (rho_A) (Dijkstra & Henseler 2015). Considering the limitations of Cronbach alpha and its conservativeness, as well as the liberal nature of the CR, rho_A is a good compromise (Hair et al. 2019). As a result, these multiple measures of internal consistency reliability were essential for construct reliability. Higher reliability coefficients suggest greater levels of reliability. Reliability for exploratory research should be at least 0.60, while 0.70 or more is advocated for established measures (Hair et al. 2019). The former criterion applies to the more recent construct, i.e., the HSI scale, whereas the latter is relevant for the remaining well-established scales. In this study, all internal reliability statistics were above the 0.7 rule of thumb (Table 4.14).

Next, convergent validity is established when the AVE is higher than 0.5 (Kline 2016). Apart from ApprsalHaz and CoworRisk, AVEs of all remaining constructs were above 0.5. This implies that those remaining constructs converge to account for the variance in their respective indicators. For discriminant validity, the AVE of each construct is compared to the squared shared variance of that same construct and all other reflectively examined constructs (Hair et al. 2019). It is expected that the square root of the AVE should be higher than any correlation with another factor (Fornell & Larcker 1981b). All the first-order constructs fulfilled this criterion (Table 4.15). Likewise, all HTMT correlations ranged from

0.053 to 0.702 and hence were below the 0.85 criteria (Henseler, Ringle & Sarstedt 2015), establishing discriminant validity among the lower and higher-order constructs (Table 4.16).

Table 4. 13: Initial outer loadings of the measurement model

Factors	AccNearMis	ApprsalHaz	Competce	CoworRisk	CurntRules	HSI1	HSI2	MgtCommit	MgtCommun	SafCom	SafPart	SuppEnv	SupvyEnv	WorkPress	Workrs
AccNearMis_1	0.932														
AccNearMis_2	0.947														
AccNearMis_3	0.95														
ApprsalHaz_1		0.697													
ApprsalHaz_2		0.657													
ApprsalHaz_3		0.686													
ApprsalHaz_4		0.68													
ApprsalHaz_5		0.776													
ApprsalHaz_6		0.649													
ApprsalHaz_7		0.65													
Competce_1			0.824												
Competce_2			0.785												
Competce_3			0.759												
Competce_4			0.851												
Competce_5			0.793												
Competce_6			0.754												
CoworRisk_1				0.803											
CoworRisk_2				0.733											
CoworRisk_3				0.709											
CoworRisk_4				0.757											
CoworRisk_5				0.684											
CoworRisk_6				0.583											
CoworRisk_7				0.643											
CurntRules_1					0.784										
CurntRules_2					0.764										
CurntRules_3					0.772										
CurntRules_4					0.756										
CurntRules_5					0.752										
HSI_6						0.764									
HSI_9						0.837									
HSI_10						0.842									

HSI_3	0.87						
HSI_4	0.901						
HSI_5	0.858						
MgtCommit_1		0.622					
MgtCommit_2		0.651					
MgtCommit_3		0.821					
MgtCommit_4		0.775					
MgtCommit_5		0.81					
MgtCommit_6		0.639					
MgtCommun_1			0.807				
MgtCommun_2			0.747				
MgtCommun_3			0.745				
MgtCommun_4			0.796				
MgtCommun_5			0.723				
SafCom_1				0.863			
SafCom_2				0.876			
SafCom_3				0.868			
SafPart_1					0.934		
SafPart_2					0.965		
SafPart_3					0.939		
SuppEnv_1						0.643	
SuppEnv_2						0.77	
SuppEnv_3						0.833	
SuppEnv_4						0.777	
SuppEnv_5						0.705	
SuppEnv_6						0.734	
SupvyEnv_1							0.743
SupvyEnv_2							0.781
SupvyEnv_3							0.644
SupvyEnv_4							0.709
SupvyEnv_5							0.773
SupvyEnv_6							0.507
SupvyEnv_7							0.764

WorkPress_1	0.737	
WorkPress_2	0.758	
WorkPress_3	0.744	
WorkPress_4	0.797	
WorkPress_5	0.81	
WorkPress_6	0.736	
WorkPress_7	0.198	
Workrs_1		0.741
Workrs_2		0.78
Workrs_3		0.72
Workrs_4		0.798
Workrs_5		0.58
Workrs_6		0.793

Table 4. 14: Construct reliability and validity of the initial measurement model

Lower-order constructs				
Factors	Cronbach's Alpha	rho_A	CR	AVE
AccNearMis	0.938	0.963	0.96	0.889
ApprsalHaz	0.821	0.82	0.861	0.471
Competce	0.883	0.89	0.911	0.632
CoworRisk	0.833	0.847	0.873	0.497
CurntRules	0.825	0.831	0.876	0.587
HSI1	0.746	0.751	0.856	0.664
HSI2	0.849	0.851	0.909	0.768
MgtCommit	0.82	0.861	0.868	0.525
MgtCommun	0.823	0.83	0.875	0.584
SafCom	0.838	0.839	0.903	0.756
SafPart	0.941	0.943	0.962	0.895
SuppEnv	0.839	0.846	0.882	0.557
SupvyEnv	0.832	0.847	0.874	0.503
WorkPress	0.821	0.878	0.869	0.506
Workrs	0.833	0.848	0.877	0.546
Higher-order constructs				
Factors	Cronbach's Alpha	rho_A	CR	
CSB	0.863	0.864	0.898	
HSI	0.828	0.83	0.875	
WSC	0.859	0.923	0.858	

Table 4. 15: Discriminant validity for lower-order constructs of initial measurement model (Fornell-Larcker Criterion)

Lower-order constructs															
Factors	AccNearMis	ApprsalHaz	Competce	CoworRisk	CurntRules	HSI1	HSI2	MgtCommit	MgtCommun	SafCom	SafPart	SuppEnv	SupvyEnv	WorkPress	Workrs
AccNearMis	0.943														
ApprsalHaz	-0.198	0.686													
Competce	-0.213	0.287	0.795												
CoworRisk	-0.242	0.538	0.266	0.705											
CurntRules	-0.397	0.543	0.376	0.546	0.766										
HSI1	0.016	0.273	0.322	0.387	0.39	0.815									
HSI2	0.013	0.131	0.276	0.163	0.277	0.503	0.877								
MgtCommit	-0.077	0.338	0.184	0.473	0.475	0.394	0.22	0.725							
MgtCommun	-0.192	0.344	0.363	0.627	0.466	0.454	0.274	0.573	0.764						
SafCom	-0.19	0.373	0.465	0.423	0.45	0.269	0.18	0.363	0.449	0.869					
SafPart	-0.237	0.23	0.274	0.288	0.304	0.24	0.154	0.274	0.352	0.441	0.946				
SuppEnv	-0.142	0.473	0.438	0.529	0.494	0.231	0.186	0.359	0.561	0.538	0.241	0.746			
SupvyEnv	-0.088	0.394	0.255	0.424	0.383	0.245	0.216	0.365	0.334	0.452	0.28	0.433	0.709		
WorkPress	0.242	-0.217	-0.256	-0.299	-0.22	-0.253	-0.12	-0.4	-0.441	-0.534	-0.312	-0.354	-0.332	0.712	
Workrs	-0.302	0.391	0.175	0.446	0.503	0.223	0.139	0.304	0.193	0.183	0.132	0.402	0.408	-0.326	0.739

Table 4. 16: Discriminant validity of initial measurement model (Heterotrait-Monotrait Ratio)

Lower-order constructs

Factors	AccNearMis	ApprsalHaz	Competce	CoworRisk	CurntRules	HSI1	HSI2	MgtCommit	MgtCommun	SafCom	SafPart	SuppEnv	SupvyEnv	WorkPress	Workrs
AccNearMis															
ApprsalHaz	0.22														
Competce	0.227	0.292													
CoworRisk	0.264	0.593	0.298												
CurntRules	0.438	0.592	0.433	0.629											
HSI1	0.053	0.313	0.393	0.446	0.493										
HSI2	0.078	0.155	0.322	0.193	0.335	0.63									
MgtCommit	0.121	0.348	0.248	0.529	0.535	0.504	0.255								
MgtCommun	0.228	0.353	0.419	0.702	0.553	0.552	0.317	0.686							
SafCom	0.211	0.381	0.545	0.472	0.538	0.337	0.214	0.445	0.526						
SafPart	0.249	0.22	0.301	0.294	0.341	0.284	0.172	0.293	0.398	0.494					
SuppEnv	0.19	0.497	0.503	0.594	0.57	0.292	0.219	0.438	0.654	0.635	0.265				
SupvyEnv	0.131	0.487	0.289	0.496	0.454	0.303	0.257	0.418	0.376	0.529	0.305	0.515			
WorkPress	0.267	0.256	0.296	0.397	0.256	0.318	0.163	0.501	0.535	0.594	0.322	0.397	0.387		
Workrs	0.343	0.468	0.241	0.499	0.58	0.256	0.176	0.367	0.243	0.21	0.156	0.468	0.477	0.387	

Higher-order constructs

Factors	CSB	HSI	WSC
CSB			
HSI	0.334		
WSC	0.613	0.43	

4.6.3 Specification and evaluation of the final measurement model

In the initial measurement model, some constructs such as ApprsalHaz and CoworRisk had lower AVEs than the 0.5 criteria. Also, indicators such as WorkPress_7 had low loadings. Thus, some items were dropped iteratively while observing the construct and scale reliability metrics. During the elimination procedure, some items exhibited validity and reliability issues, and hence were problematic for the measurement model (Hair, Howard & Nitzl 2020). After the process, the final measurement model (Figure 4.6) showed admirable factor loadings (Table 4.17), good construct reliability and validity (Table 4.18), and discriminant validity (Table 4.19).

In Table 4.17, all indicator loadings were higher than the 0.5 criterion. Also, all reliability metrics, i.e. the Cronbach's Alpha, rho_A, and CR, were above 0.7 (Hair, Howard & Nitzl 2020). For convergent validity, the AVE of each component was higher than the construct's largest squared correlation with any other latent component (Hair, Ringle & Sarstedt 2011). In addition, the HTMT correlations ranged from 0.053 to 0.797, and hence satisfied the 0.85 rule of thumb (Henseler, Ringle & Sarstedt 2015). These results confirm that the indicators of each construct adequately measure what they are intended to measure (Bagozzi & Yi 2012).

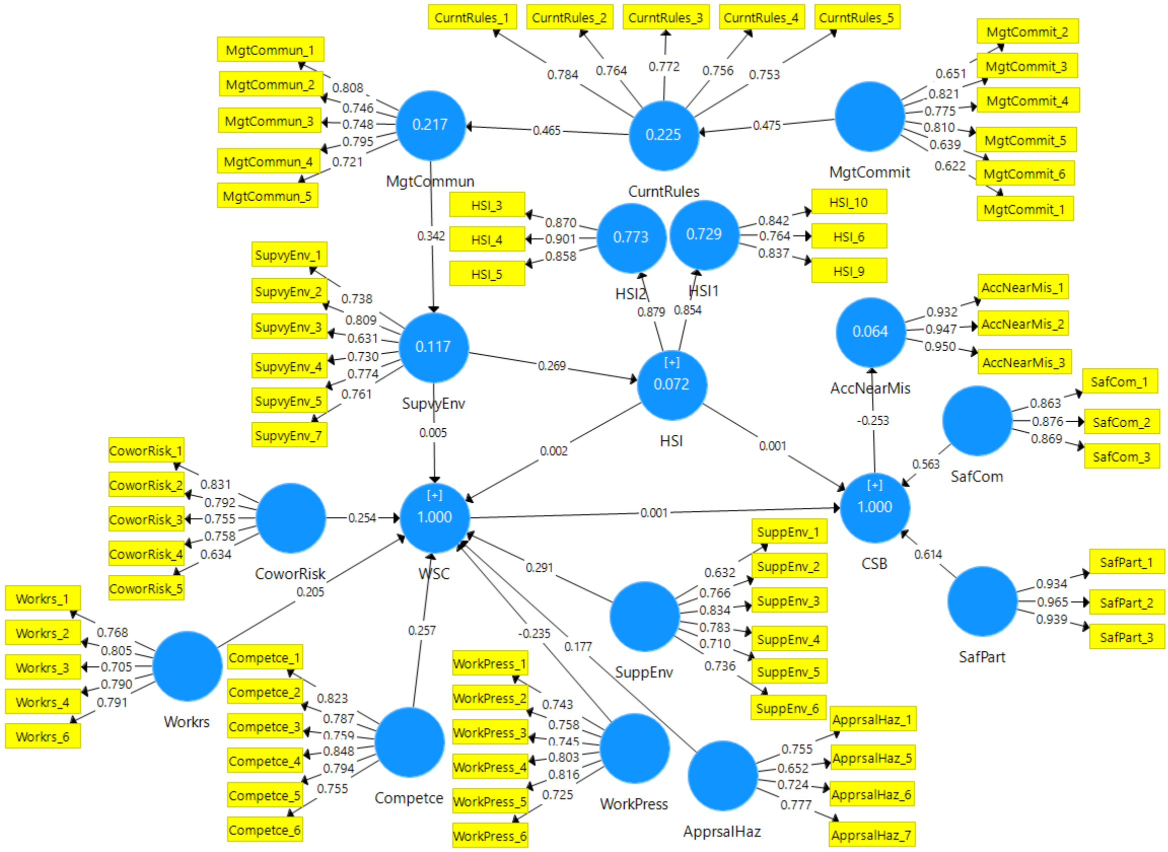

Figure 4. 6: Final measurement model

Table 4. 17: Final outer loadings of the measurement model

Factors	AccNearMis	ApprsalHaz	Competce	CoworRisk	CurntRules	HSI1	HSI2	MgtCommit	MgtCommun	SafCom	SafPart	SuppEnv	SupvyEnv	WorkPress	Workrs
AccNearMis_1	0.932														
AccNearMis_2	0.947														
AccNearMis_3	0.95														
ApprsalHaz_1		0.755													
ApprsalHaz_5		0.652													
ApprsalHaz_6		0.724													
ApprsalHaz_7		0.777													
Competce_1			0.823												
Competce_2			0.787												
Competce_3			0.759												
Competce_4			0.848												
Competce_5			0.794												
Competce_6			0.755												
CoworRisk_1				0.831											
CoworRisk_2				0.792											
CoworRisk_3				0.755											
CoworRisk_4				0.758											
CoworRisk_5				0.634											
CurntRules_1					0.784										
CurntRules_2					0.764										
CurntRules_3					0.772										
CurntRules_4					0.756										
CurntRules_5					0.753										
HSI_6						0.764									
HSI_9						0.837									
HSI_10						0.842									
HSI_3							0.87								
HSI_4							0.901								
HSI_5							0.858								
MgtCommit_1								0.622							
MgtCommit_2								0.651							
MgtCommit_3								0.821							
MgtCommit_4								0.775							
MgtCommit_5								0.81							
MgtCommit_6								0.639							

MgtCommun_1	0.808						
MgtCommun_2	0.746						
MgtCommun_3	0.748						
MgtCommun_4	0.795						
MgtCommun_5	0.721						
SafCom_1		0.863					
SafCom_2		0.876					
SafCom_3		0.869					
SafPart_1			0.934				
SafPart_2			0.965				
SafPart_3			0.939				
SuppEnv_1				0.632			
SuppEnv_2				0.766			
SuppEnv_3				0.834			
SuppEnv_4				0.783			
SuppEnv_5				0.71			
SuppEnv_6				0.736			
SupvyEnv_1					0.738		
SupvyEnv_2					0.809		
SupvyEnv_3					0.631		
SupvyEnv_4					0.73		
SupvyEnv_5					0.774		
SupvyEnv_7					0.761		
WorkPress_1						0.743	
WorkPress_2						0.758	
WorkPress_3						0.745	
WorkPress_4						0.803	
WorkPress_5						0.816	
WorkPress_6						0.725	
Workrs_1							0.768
Workrs_2							0.805
Workrs_3							0.705
Workrs_4							0.79
Workrs_6							0.791

Table 4. 18: Construct reliability and validity of the final measurement model

Lower-order constructs				
Factors	Cronbach's Alpha	rho_A	CR	AVE
AccNearMis	0.938	0.963	0.96	0.889
ApprsalHaz	0.708	0.722	0.818	0.531
Competce	0.883	0.888	0.911	0.632
CoworRisk	0.811	0.818	0.87	0.573
CurntRules	0.825	0.831	0.876	0.587
HSI1	0.746	0.751	0.856	0.664
HSI2	0.849	0.851	0.909	0.768
MgtCommit	0.82	0.861	0.868	0.525
MgtCommun	0.823	0.83	0.875	0.584
SafCom	0.838	0.839	0.903	0.756
SafPart	0.941	0.943	0.962	0.895
SuppEnv	0.839	0.848	0.882	0.557
SupvyEnv	0.837	0.847	0.88	0.552
WorkPress	0.861	0.875	0.895	0.587
Workrs	0.831	0.837	0.881	0.597
Higher-order constructs				
Factors	Cronbach's Alpha	rho_A	CR	
CSB	0.863	0.864	0.898	
HSI	0.828	0.83	0.875	
WSC	0.841	0.92	0.846	

Table 4. 19: Discriminant validity for lower-order constructs of final measurement model (Fornell-Larcker Criterion)

Factors	AccNearMis	ApprsalHaz	Competce	CoworRisk	CurntRules	HSI1	HSI2	MgtCommit	MgtCommun	SafCom	SafPart	SuppEnv	SupvyEnv	WorkPress	Workrs
AccNearMis	0.943														
ApprsalHaz	-0.232	0.729													
Competce	-0.212	0.362	0.795												
CoworRisk	-0.251	0.587	0.282	0.757											
CurntRules	-0.397	0.603	0.376	0.563	0.766										
HSI1	0.016	0.336	0.322	0.429	0.39	0.815									
HSI2	0.013	0.154	0.275	0.187	0.277	0.503	0.877								
MgtCommit	-0.077	0.409	0.185	0.533	0.475	0.394	0.22	0.725							
MgtCommun	-0.192	0.428	0.362	0.667	0.465	0.454	0.274	0.572	0.764						
SafCom	-0.19	0.456	0.465	0.46	0.45	0.269	0.18	0.363	0.449	0.869					
SafPart	-0.237	0.303	0.274	0.326	0.304	0.24	0.154	0.274	0.353	0.441	0.946				
SuppEnv	-0.141	0.545	0.44	0.543	0.493	0.232	0.185	0.357	0.563	0.541	0.243	0.746			
SupvyEnv	-0.089	0.371	0.265	0.434	0.378	0.249	0.218	0.365	0.342	0.461	0.286	0.437	0.743		
WorkPress	0.245	-0.314	-0.258	-0.358	-0.217	-0.254	-0.12	-0.398	-0.44	-0.53	-0.314	-0.349	-0.346	0.766	
Workrs	-0.297	0.378	0.204	0.476	0.506	0.24	0.153	0.307	0.218	0.197	0.149	0.402	0.407	-0.334	0.772

Table 4. 20: Discriminant validity of final measurement model (Heterotrait-Monotrait Ratio)

Lower-order constructs

Factors	AccNearMis	ApprsalHaz	Competce	CoworRisk	CurntRules	HSI1	HSI2	MgtCommit	MgtCommun	SafCom	SafPart	SuppEnv	SupvyEnv	WorkPress	Workrs
AccNearMis															
ApprsalHaz	0.3														
Competce	0.227	0.439													
CoworRisk	0.291	0.747	0.327												
CurntRules	0.438	0.764	0.433	0.682											
HSI1	0.053	0.444	0.393	0.544	0.493										
HSI2	0.078	0.195	0.322	0.226	0.335	0.63									
MgtCommit	0.121	0.493	0.248	0.628	0.535	0.504	0.255								
MgtCommun	0.228	0.524	0.419	0.797	0.553	0.552	0.317	0.686							
SafCom	0.211	0.569	0.545	0.557	0.538	0.337	0.214	0.445	0.526						
SafPart	0.249	0.346	0.301	0.37	0.341	0.284	0.172	0.293	0.398	0.494					
SuppEnv	0.19	0.686	0.503	0.64	0.57	0.292	0.219	0.438	0.654	0.635	0.265				
SupvyEnv	0.137	0.483	0.306	0.516	0.446	0.312	0.264	0.411	0.383	0.543	0.313	0.522			
WorkPress	0.255	0.365	0.291	0.405	0.243	0.305	0.155	0.475	0.51	0.585	0.331	0.374	0.39		
Workrs	0.337	0.496	0.244	0.573	0.593	0.288	0.177	0.363	0.261	0.231	0.166	0.475	0.477	0.385	

Higher-order constructs

Factors	CSB	HSI	WSC
CSB			
HSI	0.334		
WSC	0.664	0.453	

4.6.4 Specification of the structural model

After establishing the reliability and validity of the measurement model, the structural model was tested to reveal the strength and significance of the hypothesised relationships. The two-stage approach (Henseler & Fassot 2006; Henseler & Fassott 2010) was used to obtain path estimates in the structural model. The technique produces higher levels of statistical power (Hair et al. 2016) and outperforms other approaches in terms of parameter recovery (Becker, Ringle & Sarstedt 2018). Owing to this, the two-stage approach is often recommended (Hair, Sarstedt & Ringle 2019; Matthews, Hair & Matthews 2018).

The first step in the two-stage approach corresponds to the repeated indicators approach (Sarstedt et al. 2019). During this step, the PLS path model is run to obtain the latent variable scores for all higher-order constructs (Henseler & Fassott 2010). In the second stage, the latent variable scores are then saved and used to specify the model for further analysis. As a result, only higher-order constructs are considered in the structural model (Sarstedt et al. 2019).

Also, the two moderating effects hypothesised in this study were specified in the structural model (Figure 4.7). Each interaction term was created on the endogenous variable from the product of the exogenous and moderator variables (Chin, Marcolin & Newsted 2003). A complete bootstrapping of 5000 samples was used, since larger samples yield stable results. A 95% significance level with a two-sided significance test was specified for all computations. In estimating the confidence intervals, the Bias-Corrected and Accelerated bootstrap method was employed, since it is the most stable approach and does not need excessive computing time (Efron 1987; Ringle, Wende &

Becker 2015). A maximum of 2000 iterations was set to estimate the structural model results.

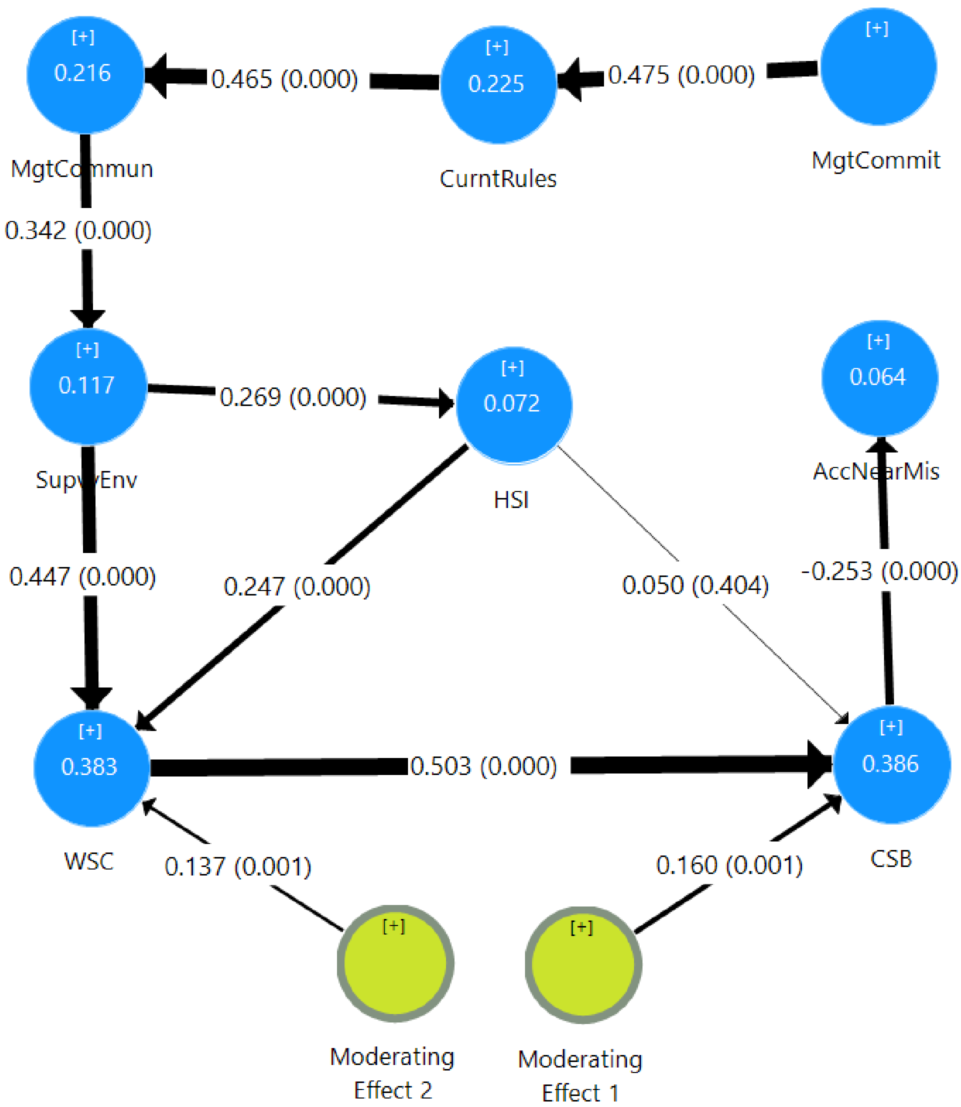

Figure 4. 7: Structural model with path coefficients and p-values

4.6.5 Assessment of the structural model

There have been ongoing debates surrounding the limitations of having stringent criteria within the SEM field (Kenny & McCoach 2003). Owing to this, numerous researchers have scrutinised and made calls to completely abolish fit indices (Barrett 2007). Moreover, fit indices may suggest a well-fitted model when, in reality, the model may fit poorly

(Reisinger & Mavondo 2007). Relevant to this discussion, whereas CB-SEM strongly depends on the concept of model fit, this is much less the case with PLS-SEM (Hair, Sarstedt & Ringle 2019), because CB-SEM models largely rely on the covariance matrix. Moreover, Chi-square-based model fit measures and associated extensions in CB-SEM are not applicable in PLS-SEM (Hair et al. 2019). As a result, the application of goodness-of-fit measures on PLS-SEM should be done with caution (Henseler & Sarstedt 2013). For this study, the coefficient of determination (R^2), statistical significance and relevance of the path coefficients were used in assessing the structural model (Hair et al. 2019).

The R^2 suggests the total variance explained in each input feature. R^2 values should be interpreted with caution, since different contexts call for varied R^2 values. For example, in predicting stock returns, an R^2 value of 0.10 is regarded as satisfactory (Shmueli & Koppius 2011). Unlike inherently predictable concepts, like physical processes where an R^2 of 0.90 is considered reasonable, having similar R^2 values when predicting human attitudes, perceptions and intentions are likely to indicate an overfit (Hair et al. 2019). Overfitting is problematic to model generalisation and out-of-sample prediction. In line with this discussion, the R^2 values obtained in this study ranged from 0.064 to 0.386 (Table 4.21). These coefficients were deemed significant at the 95% confidence interval. Worth noting, as the R^2 is a function of the number of exogenous constructs, the greater the number of such constructs, the higher the R^2 value (Hair et al. 2019). As observed in Figure 4.7, endogenous constructs with single predictors had relatively low R^2 values, while those with three predictors had higher R^2 values.

Table 4. 21: R-square statistics

Factors	Coef.	Stdev.	T-statistics	P-values	95% CI Lower	95% CI Upper
AccNearMis	0.064	0.028	2.282	0.023	0.020	0.127
CSB	0.386	0.045	8.592	0.000	0.299	0.476
CurntRules	0.225	0.049	4.629	0.000	0.138	0.329
HSI	0.072	0.035	2.043	0.041	0.020	0.156
MgtCommun	0.216	0.048	4.500	0.000	0.130	0.317
SupvyEnv	0.117	0.041	2.858	0.004	0.048	0.208
WSC	0.383	0.051	7.472	0.000	0.286	0.484

Twelve out of the thirteen hypotheses were supported (Table 4.22). Co-workers' safety behaviour (CSB) has a significant negative effect on co-workers' safety outcomes (AccNearMis). This suggests that, as the safety behaviour of co-workers increases, the number of accidents and near-misses decreases. Current safety rules and procedures (CurntRules) has a significant positive effect on management communication (MgtCommun). Human safety interventions (HSIs) is positively related to co-workers' safety behaviour. However, this relationship is not significant. Human safety interventions have a significant positive influence on workgroup safety climate (WSC). Management commitment (MgtCommit) has a significant positive effect on current safety rules and procedures. Management communication has a significant positive effect on supervisory environment (SupvyEnv). Supervisory environment has a significant positive effect on human safety interventions. Supervisory environment has a significant positive influence on workgroup safety climate. Workgroup safety climate has a significant positive positive effect on co-workers' safety behaviour.

Next, mediating and moderating effects were examined. Mediating effects were examined to test whether a change in the exogenous factor yields a change in the mediator factor, which in turn yields a change in the exogenous factor (Matthews, Hair & Matthews 2018; Nitzl, Roldan Jose & Cepeda 2016). In this study, co-workers' safety behaviour significantly mediates the relationship between workgroup safety climate and co-workers' safety outcomes. However, this mediation was partial since the direct effect of WSC on AccNearMiss was significant, even when the mediator, WSC, was included in the model. Also, human safety interventions partially mediate the relationship between supervisory environment and workgroup safety climate.

Further, the study examined moderation effects. There is moderation when the relationship between two factors changes as a result of the third factor (moderator) (Henseler & Chin 2010). Human safety interventions significantly moderate the relationship between workgroup safety climate and co-workers' safety behaviour. Also, human safety interventions significantly moderate the relationship between supervisory environment and workgroup safety climate. Figures 4.8 and 4.9 show the interacting effects hypothesised in this study. As human safety interventions increase, the effect of workgroup safety climate on coworkers' safety behaviour also increases (Figure 4.8). Likewise, as human safety interventions increase, the effect of supervisory environment on workgroup safety climate increases (Figure 4.9). Using relative values, the study also highlights the most significant paths to reducing the number of accidents and near-misses. This is illustrated by the weight of the lines in Figure 4.7.

Table 4. 22: Assessment of the structural model

Relationship					95% CI		
Direct effects	Path coef.	Stdev.	T-statistics	P-value	Lower	Upper	Decision
CSB -> AccNearMis	-0.253	0.056	4.513	0.000	-0.357	-0.141	Accept
CurntRules -> MgtCommun	0.465	0.052	8.984	0.000	0.361	0.563	Accept
HSI -> CSB	0.050	0.060	0.835	0.404	-0.071	0.164	Reject
HSI -> WSC	0.247	0.052	4.768	0.000	0.147	0.351	Accept
MgtCommit -> CurntRules	0.475	0.051	9.222	0.000	0.371	0.573	Accept
MgtCommun -> SupvyEnv	0.342	0.060	5.665	0.000	0.220	0.456	Accept
SupvyEnv -> HSI	0.269	0.065	4.139	0.000	0.143	0.395	Accept
SupvyEnv -> WSC	0.447	0.047	9.523	0.000	0.351	0.536	Accept
WSC -> CSB	0.503	0.057	8.860	0.000	0.384	0.610	Accept
Mediating effects							
WSC -> CSB -> AccNearMis	-0.127	0.034	3.718	0.000	-0.196	-0.063	Accept
SupvyEnv -> HSI -> WSC	0.066	0.023	2.871	0.004	0.028	0.118	Accept
Moderating effects							
WSC_x_HSI -> CSB	0.160	0.049	3.279	0.001	0.067	0.262	Accept
SupvyEnv_x_HSI -> WSC	0.137	0.041	3.326	0.001	0.057	0.215	Accept

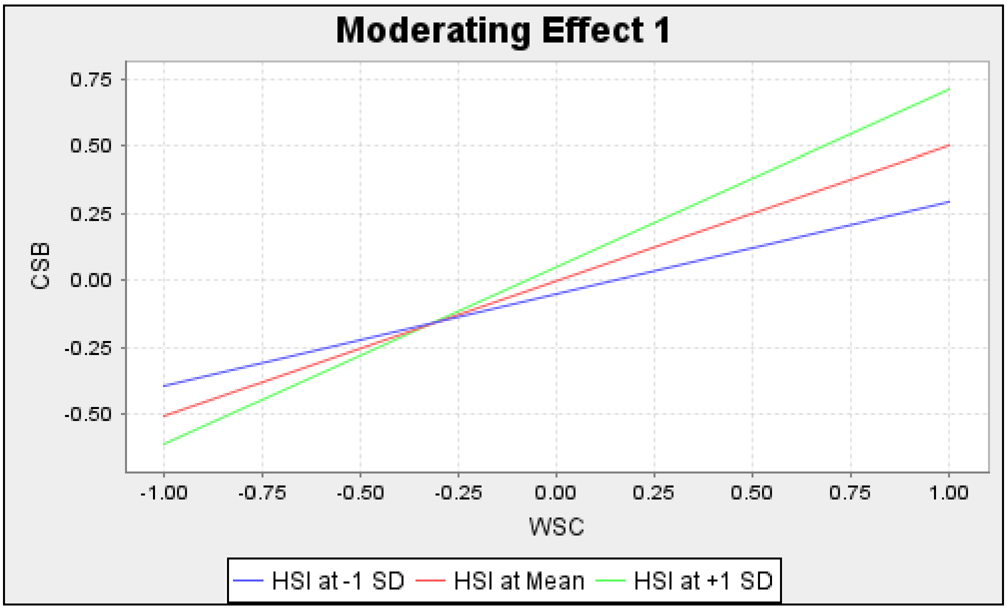

Figure 4. 8: Two-way interaction: moderation effect 1

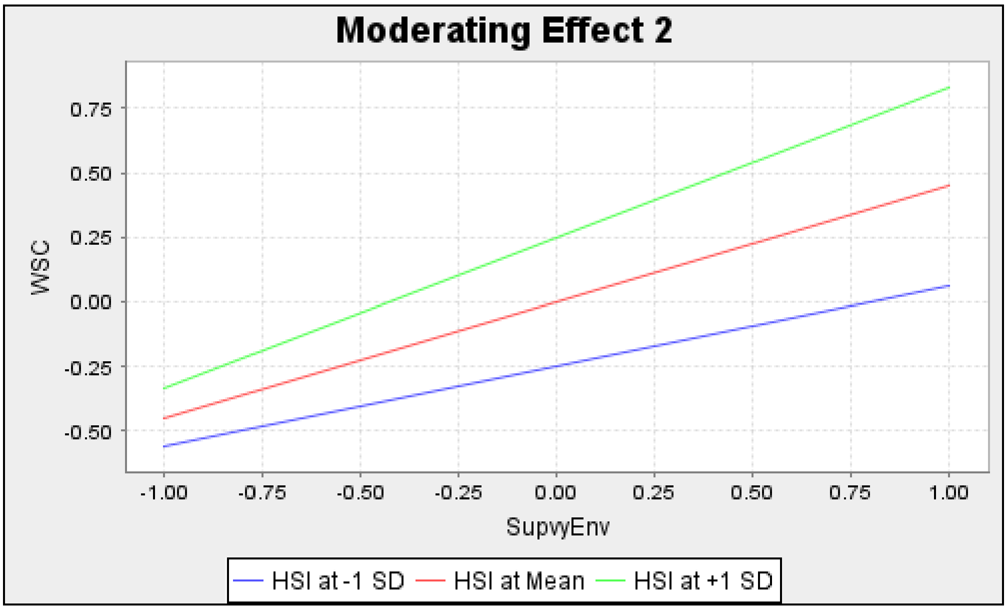

Figure 4. 9: Two-way interaction: moderation effect 2

The model in Figure 4.10 was estimated separately, since when it is included in the earlier structural model (Figure 4.7) it renders the model incalculable. There is a significant negative relation between safety outcomes and workgroup safety climate (Table 4.23). This suggests that safety outcomes provide important cues to workers and hence influence the formation of workgroup safety climate. As such, as safety outcomes such as accidents and near-misses increase, it informs workers about the priority of safety at the workplace. The model also has a statistically significant R^2.

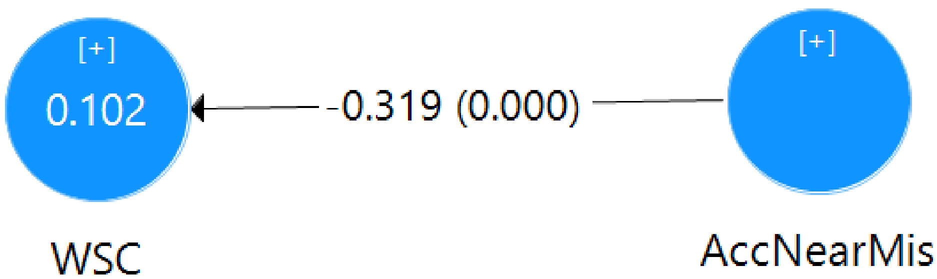

Figure 4. 10: Structural model with path coefficients and p-values

Table 4. 23: Assessment of the structural model

Relationship					95% CI	
Direct effect	Path Coef.	Stdev.	T-statistics	P-values	Lower	Upper
AccNearMis -> WSC	-0.319	0.057	5.579	0.000	-0.430	-0.206

Table 4.24: R-square statistics

					95% CI	
Factors	Coef.	Stdev.	T-statistics	P-values	Lower	Upper
WSC	0.102	0.036	2.794	0.005	0.042	0.185

4.7 Robustness check

As a form of robustness check, the data was divided into two using a simple non-random approach. This technique is relevant for this assessment as random approaches tend to balance the skewness in sample distribution among datasets. However, the true robustness of the model is evident when there are possibilities of one sample being differently distributed than the other. This suggests that the researcher has little effort to control the sample composition in the quest to attain similar results on the two datasets. One group with the first 148 samples in the dataset, and the other with the remaining 149 observations. This assessment examined the replication power of the structural models across diverse sample distributions. In all cases (Figures 4.11-4.14), the models exhibited good generalisability and consistency when compared with the main models (i.e., Figures 4.7 and 4.10). The significant paths to reducing accidents and near-misses also remained the same in both samples when compared with the main model.

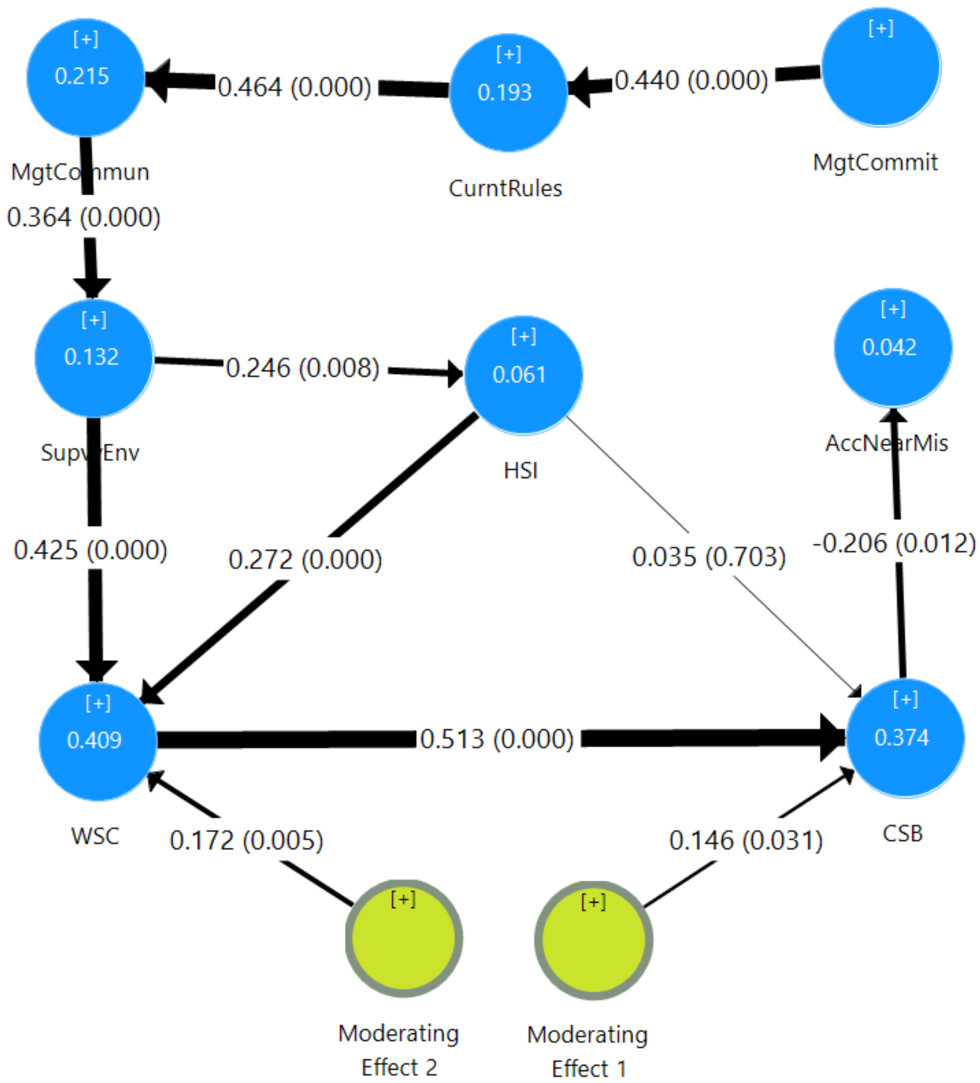

Figure 4. 11: Structural model for robustness check (N=148)

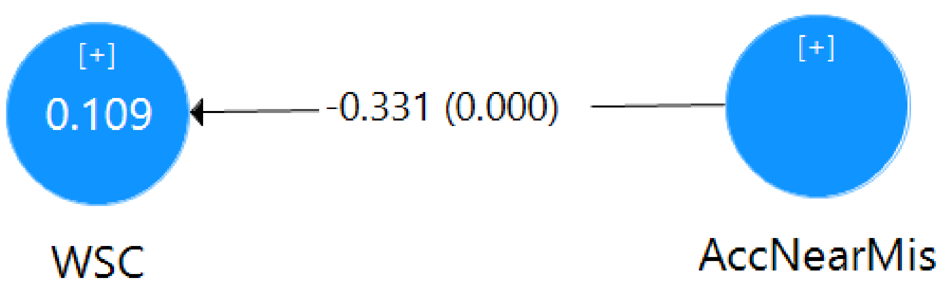

Figure 4. 12: Structural model for robustness check (N=148)

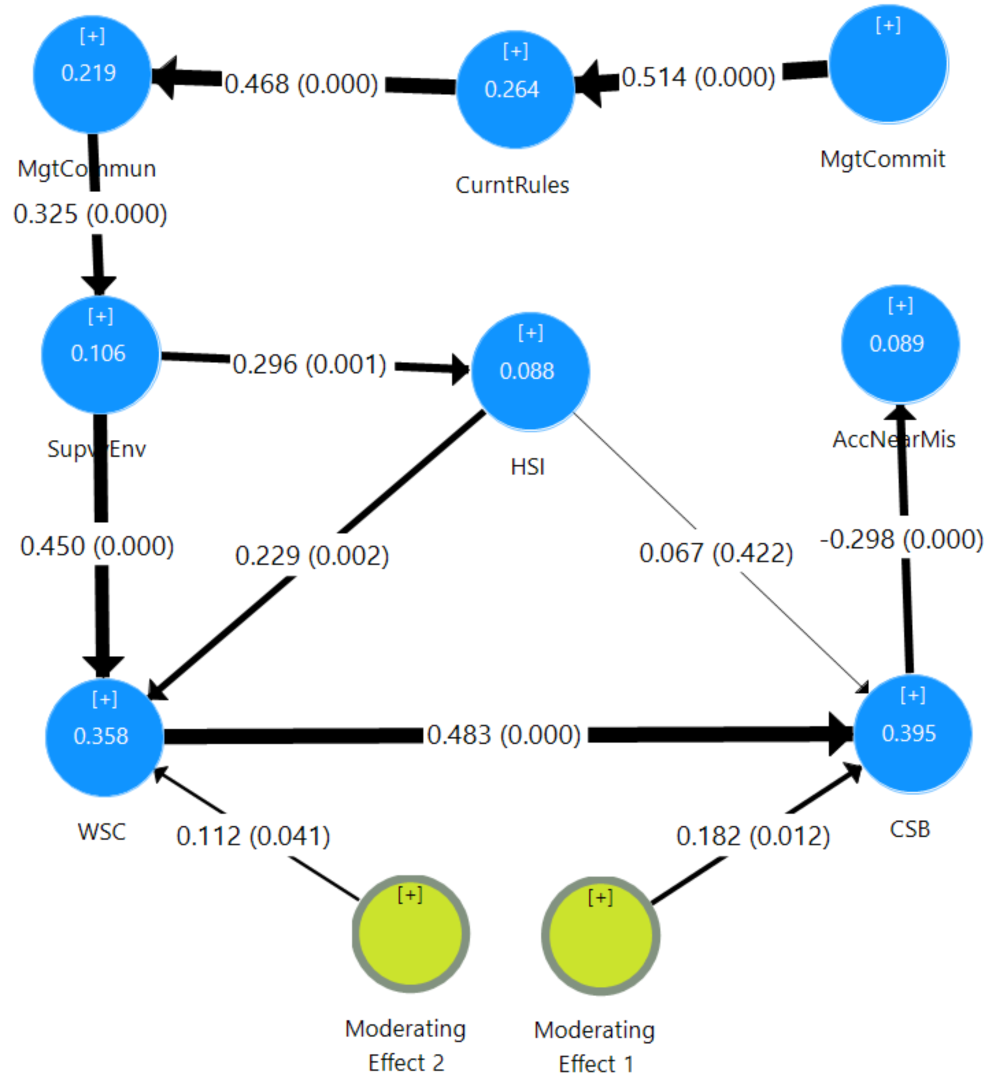

Figure 4. 13: Structural model for robustness check (N=149)

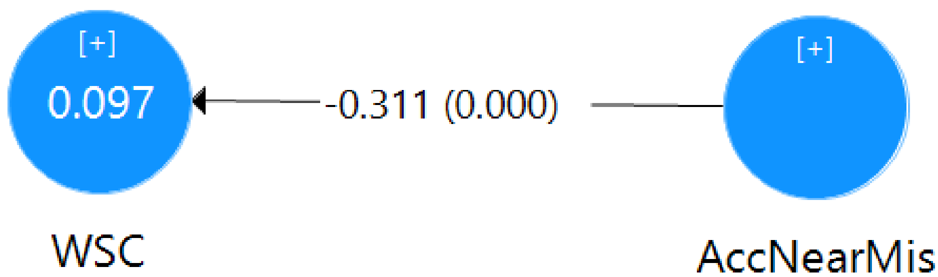

Figure 4. 14: Structural model for robustness check (N=149)

4.8 Chapter Summary

This chapter presented the empirical findings of the research. The socio-demographic profile of the participants was initially described. Descriptive and reliability analyses were performed on the HSI construct, given its novelty. The tests showed that data for the HSI construct is normally distributed, no multicollinearity issues among items, and good consistency in responses. EFA was then performed on the HSI construct to identify any underlying structures among its items. The results revealed two factors, with seven items under the first factor and the remaining five comprising the second factor. CFA was then used to confirm the factor structure proposed by the EFA by performing construct validity and model fit tests. After careful modifications, the two factors of the HSI construct had three items under each. The validated HSI construct was then integrated into the research model. PLS-SEM was used to specify and evaluate the measurement and structural models derived from the research model. At the end of the assessments, thirteen out of the fourteen hypotheses were supported. Although HSI has a positive influence on co-workers' safety behaviour, this effect was not significant. Finally, a robustness check was performed to confirm the replication power of the model. The results in this chapter are theoretically explained in the next chapter.

5 DISCUSSION OF THE RESULTS

5.1 Introduction

This chapter discusses the results obtained in the previous chapter. It provides further conceptualisations and explanations for the human safety interventions scale. The chapter also seeks to understand why certain hypotheses were accepted and the reasons for rejecting others. Specifically, theoretical justifications are provided to support the empirical results presented in Chapter Four.

5.2 Human Safety Interventions

This study sought to develop and validate the construct of human safety interventions (HSIs) in construction projects. This scale drew on the work of Zaira & Hadikusumo (2017) who identified 15 practices in HSIs. The questionnaire is psychometrically sound, with good fit and validity. It follows a more robust aggregation strategy, the referent-shift approach, which is also well aligned with the multilevel model of analysis. The validated questionnaire comprises two factors (with three items under each): psychological safety interventions (HSI1) and sociological safety interventions (HSI2). The psychological safety interventions comprised of HSI_6, HSI_9, and HSI_10, whereas the sociological safety interventions comprised of HSI_3, HSI_4, and HSI_5 (Figure 4.4). Thus, the stability of a factor was defined by the factor having at least three variables loading on it both substantively and distinctively (Arrindell et al. 1983; Hair et al. 1995; Walker 2010).

Though distinct, an interplay between the psychological safety interventions and sociological safety interventions is expected, particularly because of their mutuality in explaining various phenomena (Thoits 1995). This was evident in the factor correlation matrix (Table 4.8), suggesting that there is at least 10% overlap in the variance among the two factors when the correlation exceeds 0.32 (Tabachnick & Fidell 2007).

Considering the initial factor correlation of 0.561 during the scale development, increasing to 0.62 (Figure 4.4) at validation, there is about 20% overlap between the two factors in this study.

There is a risk that well-driven interventions to augment safety that do not consider a wider array of interrelating social-psychological aspects may fail, or even be counter-productive (Törner 2011). As such, this interplay between the two factors is important, as it offers opportunities for cross-fertilisation by considering contextual and structural constraints associated with a unidimensional view when offering insights on safety events, suggesting that the two factors can be regarded as reflective-reflective higher-order constructs. With such factors, there is a possibility of item substitution, good positive correlation, similar indicator antecedents and consequences, and a unidimensional nature (Bollen & Lennox 1991; Jarvis, MacKenzie & Podsakoff 2003).

It is expected that the two reflective factors tap into the same underlying concept or phenomenon (Chin 1998). Hence, reflective indicator loadings, convergent and discriminant validity, as well as reliability and internal consistency, should be considered when evaluating these constructs (Hair et al. 2019; Xiong, Skitmore & Xia 2015). In explaining the two constructs, some items that were eliminated during the CFA but retained at the EFA stage were included to support the discussions, primarily because of the ongoing debates surrounding the limitations of having stringent criteria within the SEM field (Kenny & McCoach 2003). As a result, some items may have been wrongly eliminated in the quest to satisfy model fit.

5.2.1 Psychological safety interventions

Psychological safety interventions suggest methods to alter workers' perceptions of safety practices, risks, and uncertainties. This construct is guided by learning behaviour, prospect, and social exchange theories. Consistent with the social exchange theory, when an organisation is thought to fulfil their duties, care for workers fairly, and offer valued services and benefits, workers reciprocate with higher levels of commitment and performance (Mearns et al. 2010). As such, social externalities impact others as an effect of the decision of the decision-maker (Zohar & Erev 2007). For instance, it is expected that when adequate safety supervision (HSI_7) is provided to workers, they reciprocate by working safely. Workers become aware of the desired behaviour that is encouraged and supported by their supervisors or managers, hence reducing the degree of ambiguity linked to their daily "safety roles" during work. As a result, supervisors provide important cues for workers to use to determine the priority and value of safety practised in their workgroups (Zhang, Lingard & Nevin 2015).

Fundamentally, psychological safety interventions target the reduction of interpersonal risks in times of uncertainty and change (Schein & Bennis 1965). For example, easy access to safety information (HSI_6) and provision of safety awareness programs (HSI_8) are essential for reducing risks and fostering continuous growth (Zou 2011). Among other reasons, unlike having to seek information, the availability of safety information and the improvement in employee safety due to the implementation of safety programs minimise the risk of being seen as ignorant, incompetent, negative, or disruptive (cf. Edmondson 2003). By learning behaviour, workers become knowledgeable and mindful about safety hence reducing the anxiety associated with confronting ambiguity, changes and uncertainty when conducting their daily activities.

In contrast with the psychological safety climate, which forms at the individual level, psychological safety interventions are a group-level construct. Because it is distinct from other industries, in that the nature of the construction industry offers daily possibilities for social interaction with co-workers (Lingard, Cooke & Blismas 2010a; Zohar et al. 2014), psychological safety interventions thrive within the construction industry, where workers are in physical and social proximities. As such, workers who work closely together tend to have similar perceptions of psychological safety due to shared experiences and identical contextual influences (Edmondson, Kramer & Cook 2004).

Besides, the aggregation model employed in this study connotes a shared perceptual view about HSIs. The workgroup is therefore the most proximal and prominent social unit in the organisation (Ashforth 1985). As reasoned by Schein (1993), "with psychological safety, individuals are free to focus on collective goals and problem prevention rather than on self-protection" (Edmondson & Lei 2014, p. 25). Given this, psychological safety interventions could modify the value function of safety behaviour. Such interventions have been known to reduce the perceived costs associated with working safely (Zohar & Erev 2007). For example, the use of publicly displayed safety bulletin boards (HSI_11) depicting performance feedback was found to improve safety performance (Lingard & Rowlinson 1997). Such open feedback is essential because individuals are usually reluctant to seek feedback about their performance (Edmondson 2003) since they do not want to be seen as intrusive (Brown 1990), among other reasons. As such, psychological safety interventions help workers overcome defensiveness or "learning anxiety" (Schein 1985).

Likewise, viewed through the lens of Prospect theory, the introduction of frequent short-term incentives (HSI_10) counteracts the tendency to underweight the long-term benefits of safe conduct (Zohar & Erev 2007, p. 132). This is in line with behaviour-based safety (BBS) (HSI_9) (Geller, Roberts & Gilmore 1996), as its focus is centred on particular safety-related behaviour that is mostly exhibited by workers (Krause, Hidley & Lareau 1984). BBS, therefore, creates a collective responsibility between managers and employees for safe work behaviour (Lingard & Rowlinson 2005; Loosemore & Malouf 2019). Also, when workers get the required safety certification (HSI_12), project team members are stimulated to sustain a good level of safety performance (Rajendran & Gambatese 2009). The training acquired during these safety certifications are relevant, as they provide the tacit knowledge for facilitating the decision-making process when workers are faced with competing demands (e.g., production versus safety) or during times of uncertainties.

5.2.2 Sociological safety interventions

This study defines sociological safety interventions as safety practices that improve workers' knowledge and reasoning concerning safety through socially related activities at work. This construct follows the sociological theory of industrial accidents which posits that "industrial accidents are produced by social relations of work" (Dwyer & Raftery 1991). According to this perspective, greater integration of workers concerning safety issues could be expected to minimise accidents. For example, when management initiates safety campaigns (HSI_4), it informs workers about the primacy of safety over other competing company goals, and hence workers feel valued and appreciated (Törner 2011).

Such activities encourage social ties and friendships and hence need to be regarded as highly influential on performance outcomes (Zohar & Tenne-Gazit 2008). This development of friendships and social and emotional ties between crew members will increase the degree to which co-workers develop considerate and responsible attitudes towards each other (Burt, Sepie & McFadden 2008). A supportive environment is therefore the most important factor in influencing workers' safety attitudes (Mohammadfam et al. 2017). Similarly, to boost workers' safety attitudes, it is recommended that their participation in safety-related activities, such as hazard analysis (HSI_5), should be promoted (Mohammadfam et al. 2017). In addition, when hazard analysis is carried out it helps to identify safe and unsafe practices (Lingard & Rowlinson 1997).

The sociological safety interventions follow the view that safety events that offer opportunities for social interactions exert greater influence on socially proximal individuals (cf. Erickson 1988). In other words, through symbolic interactions, individuals influence specific and generalised others in the social order (Thoits 1995). For example, when workers are provided with adequate safety training (HSI_1), they tend to have a strong awareness of what constitutes safe and correct practice, thereby reducing the risks to themselves as well as others (Wilkins 2011).

Likewise, safety inductions given to new workers (HSI_3) form an integral part of the organisation (Umar 2020), which further leads to fewer injuries (Kinn et al. 2000). For instance, the implementation of safety inductions for new workers and the provision of toolbox training (HSI_2) resulted in a 15% and 36% increase in safety performance over the previous month, respectively (Cameron & Duff 2007). Owing to such advantages, the use of regular toolbox meetings is encouraged (Kaskutas et al. 2013) and viewed as a valued form of communication in the construction industry (Jeschke et al. 2017). These activities promote shared safety goals among the workers and their organisation. Thus interventions that increase organisational identity and participation signal inclusion and status in the organisation (Joensson 2008). Interactions during such activities have been found to predict group safety climate (Kines et al. 2010; Zohar & Tenne-Gazit 2008).

5.3 Discussion of Hypotheses

This section presents the theoretical and literature-based justifications to support the empirical results presented in Chapter Four. Out of the fourteen hypothesised relationships, one was rejected. Explanations are provided for rejecting and accepting other hypotheses. Considering that almost all the hypotheses were accepted, discussions presented in this section further validate the research model, hence fulfilling the fourth and fifth research objectives. Overall, the justifications provided in this section addresses the research aim by confirming the role of HSIs on the impact of workgroup safety climate and on co-workers' safety behaviour in construction projects.

5.3.1 Management commitment has a positive relationship with current safety rules and procedures

The study proposed that management commitment would be positively related to current safety rules and procedures. This suggests that when management is committed to safety matters, they would create practical and efficient safety rules and procedures. Table 4.22 provides empirical support for this hypothesis. Rules have positive social psychological effects on workers (Adler & Borys 1996). According to the theory of effective rules, organisations are expected to establish rules that are technically applicable and acceptable to the people who must explain, implement, or adhere to such rules (DeHart-Davis 2009). These rules and procedures set by the organisation draw the boundaries for expected behavioural norms (Zohar & Luria 2005). From the effective rules view, ineffective rules lead to negative organisational impacts (Scott & Pandey 2000). Such inefficient rules and procedures are a major cause of accidents on construction sites, since they encourage inadequate implementation of safety management systems and technical measures (López Arquillos, Rubio Romero & Gibb

2012; Sawacha, Naoum & Fong 1999; Suraji, Duff & Peckitt 2001). For example, Loosemore, Sunindijo & Zhang (2020) found that construction workers in Australia perceive that some safety rules and procedures are not realistic to implement. As a result, many workers believe that challenging the prevailing safety rules in most instances is appropriate (Safe Work Australia 2015c).

The effective implementation of safety management rules and policies in construction projects mostly relies on the commitment and actions of management, on whom power rests (Fang et al. 2020). Management has the power to assign resources and enforce the organisation's policies (Sunindijo & Zou 2012). Hence, their commitment is vital for the effectiveness of safety initiatives in the organisation (Lingard & Rowlinson 1997), and a major contributor to the success of safety programs (Zohar 1980). Management can therefore show their commitment by expressing concern if safety procedures are not adhered to (MgtCommit_2). On the other hand, uncommitted safety leadership leads to ineffective rules and procedures that could trigger rebellion/superficial compliance or noncompliance (cf. Barakat 1969; Fang et al. 2020), whereas there is increased compliance with safety rules and procedures when management is committed (Wu et al. 2015). Developing effective rules and procedures requires managers to dedicate more time to learning novel techniques, supervising employees and dealing with paperwork (Niskanen, Louhelainen & Hirvonen 2016; Soares & Barnett 2008). Therefore, an increase in management commitment positively influences the current safety rules and procedures (cf. Gilkey et al. 2011; Hale & Borys 2013).

In this context, management can show their commitment by creating realistic and useful safety rules and procedures. This is important because studies in Australia such as

Schriever (2014); WorkCover Queensland (2019) indicate that OHS is often compromised by burdensome bureaucracy, overregulation and paperwork, making it difficult for construction workers to comply with such rules (Loosemore et al. 2019a; Loosemore, Sunindijo & Zhang 2020). It is not sufficient for workers to simply comply with the safety regulations (Curcuruto, Parker & Griffin 2019). Encouraging and consulting with employees can help management arrive at a set of rules and regulations agreed upon by all, as practical. These suggest that management commitment to safety can be reflected in their decision and policy making, active involvement in OHS matters, active communication with the workforce, influence on organisational practices, and their safety values (Fruhen et al. 2014; Zohar & Luria 2005). In summary, the ability of managers to solve problems, effectively socialise with workers, and acquire the requisite safety knowledge conveys their safety commitment throughout the organisation (Fruhen et al. 2014), which would lead to the creation of more practical safety rules and procedures.

5.3.2 Current safety rules and procedures have a positive relationship with management communication

The study suggested that current safety rules and procedures would be positively related to management communication. This hypothesis was empirically supported, as shown in Table 4.22. Once safety rules and procedures are instituted, management can communicate them to make workers aware of these fundamental organisational properties (Alruqi, Hallowell & Techera 2018). These policies, rules and procedures must be perceived by workers as applicable, reasonable, and useful (Zou & Sunindijo 2015). Thus, workers' perceptions are reflected in the safety rules, procedures and goals provided to them by management (Khawam & Bostain 2019). Then, supervisors execute and enforce these policies and associated procedures through frequent decisions and interactions with workers (Zohar 2008).

The organisation's policies, procedures, and practices, when communicated to the employees, suggest the calibre of behaviour that is rewarded and encouraged at the workplace (Reichers & Schneider 1990). Also, irrespective of the most stringent safety rules and abundant resources, inadequate safety communication can lead to unsatisfactory safety outcomes (Zamani, Banihashemi & Abbasi 2020). To curb this, management can promote worker awareness and comprehension of the prevailing safety rules and procedures through better safety communication (Alruqi, Hallowell & Techera 2018). This can be done by adopting validated programs such as *See the Difference* program, which was developed by Love et al. (2017) to make workers conscious about their safety actions and integrate safety into daily site routines. As a result, the current safety rules and procedures developed and endorsed by management influences how the organisation communicates their safety expectations, hence conveying the organisational priorities to workers (cf. Weiss 1977; Zohar 2000). Therefore, an increase in the prevailing safety rules and procedures affects management communication.

Safety programs, initiated due to an organisation's goals, are known to be effective when managers are available to discuss the programs with workers, whereas safety programs are ineffective when management seemed to dissociate from safety matters in the organisation (Harper et al. 1996). As a result, management can encourage feedback from workers (MgtCommun_3) and operate an open-door policy on safety issues (MgtCommun_4). In addition, managers can use toolbox meetings as a platform to brief personnel at all levels about safety priorities in the organisation. Face-to-face meetings between managers and employees is a key characteristic that differentiates safety success from failure (Harper et al. 1996). For the reason that, sometimes, workers may have greater awareness of the prevailing safety rules and procedures, but still not care about safety (cf. Loosemore & Malouf 2019). This personal manager-to-worker communication (Fruhen et al. 2014) improves the affective feature of workers safety attitude. Managers can also use new technologies such as virtual reality to immerse workers in a simulated environment which demonstrates the application of organisational safety procedures (Newton, Wang & Lowe 2015). This helps to create a stronger emotional link with safety matters and heightens the relevance of safety (Loosemore & Malouf 2019; Sunindijo & Zou 2013).

Likewise, in instances when management is consistent in applying the rules and procedures themselves, it sends an important message to workers on the value and expectations of safety. For example, when company rules suggest all should wear helmets, but managers fail to wear them themselves on site, it communicates contradictions between what workers are supposed to do and what they must actually do. Similarly, considering that safety is an abstract goal, managers can employ their skills of persuasion to drive others of the relevance of safety (Hale 2009). Good safety leadership skills, therefore, enhance the effectiveness of communicating the organisational safety rules and regulations.

5.3.3 Management communication has a positive relationship with supervisory environment

The study proposed that management communication would be positively related to the supervisory environment. This means that when management effectively communicates their safety expectations, supervisors would put more effort into realising the safety goals. This hypothesis was supported by the empirical results presented in the previous chapter. Members of an organisation carry out their work through roles (Dienesch & Liden 1986). Roles have been acknowledged as messengers of information to individuals in an organisation (Jackson & Schuler 1992). As a result, the kinds of roles people play in an organisation will determine their perception and interpretation of inbound information (Katz & Kahn 1978). Drawing on role theory, it may be observed that supervisory roles are moulded by the needs of the system in which they are embedded (Katz & Kahn 1978; Stryker & Serpe 1982). From this view, managers can instruct supervisors (Yukl 2004). This suggests that immediate supervisors are likely to be extremely influential "role senders" in an organisation (Shivers-Blackwell 2004). When management emphasises safety as a priority, supervisors tend to be more concerned with safety issues (Cheung & Zhang 2020; Zohar 2002a). Consequently, supervisors' safety roles act as a mediator between the management and workers (Newaz et al. 2020).

The magnitude of the organisational expectations and goals communicated to supervisors influences the degree to which they are viewed as representatives of the organisation and affirm their assigned duties (Eisenberger et al. 2010; Vandenberghe, Bentein & Panaccio 2017; Venkataramani, Green & Schleicher 2010). Therefore, expectations communicated by management will affect the supervisory practice (Bacharach, Bamberger & Sonnenstuhl 1996; Zohar 2002a). This management communication-supervisory environment association is important because supervisors are traditionally the nearest organisational link to the workers, and can communicate the organisation's goals directly to the workers (Pati & Kumar 2010). As a result, supervisors play a key role in transforming the company's safety policy commitment into safety standards and practices (Newaz et al. 2020). Also, supervisors' safety responses are strongly linked with the organisational safety response (Meliá et al. 2008). Supervisors are therefore perceived as personal extensions of organisations (Eisenberger et al. 1986).

Given these discussions, an increase in management communication would positively influence the supervisory environment. These discussions suggest that the expectations of management are actualised when supervisors hold safety in high priority (Newaz et al. 2020).

It is important that there is a mutual relationship between the safety agents, such as supervisors, managers, and workers. This mutual relationship often referred to as the psychological contract of safety, is theorised as the individual perceptions on shared safety obligations between the employer and employee (Walker 2010). Extending the application of the theory from existing evidence on how psychological contract of safety explains the mutual obligations between supervisors and workers on construction sites (e.g. Newaz et al. 2019a; Newaz et al. 2020), the mechanisms through which management communication influence supervisory environment could further be explored using this theoretical lens since supervisors are employed by the management.

A psychological contract occurs when an individual perceives that promises made by an employer are contingent upon reciprocal actions of the employee (Rousseau 1990). There is a violation of contract when the promises and obligations of the contract are not fulfilled by a party, thereby leading to a reduction in the quality of the exchange relationship (Morrison & Robinson 1997; Rousseau 1995). Even though supervisory roles will entail some personal discretion over how to implement current organisational rules and policies, the expectations communicated by top management will impact supervisory practice, leading to an equilibrium whose specific level reflects the agreed preferences of both parties (Bacharach, Bamberger & Sonnenstuhl 1996; Zohar 2002a). For example, when senior managers assign a higher priority to safety, supervisors will be morally obligated to reciprocate by placing greater concern on safety matters.

5.3.4 Supervisory environment has a positive relationship with human safety interventions

The study hypothesised that supervisory environment would be positively related to human safety interventions. From the statistical analyses, this hypothesis was supported. This suggests that when there is a positive supervisory environment there would be greater effectiveness in implementing human safety interventions. A positive supervisory environment occurs when a supervisor; sets good safety examples to workers (SupvyEnv_1), believes safety is paramount (SupvyEnv_2), engages in regular safety talks (SupvyEnv_3), welcomes reporting safety hazards/incidents (SupvyEnv_4), serves as a good resource for solving safety problems (SupvyEnv_5), advocates working with safety procedures to meet important deadlines (SupvyEnv_6), and values workers' ideas about improving safety when significant changes to working practices are suggested (SupvyEnv_7).

Considering that HSIs are practices and programs, supervisors play a key role in ensuring their implementation success. In the same vein, supervisors' competencies have been identified as essential in facilitating the effectiveness of OHS practices (Finneran et al. 2012; Yiu, Sze & Chan 2018), given that supervisors make micro-decisions daily as they implement management policies and procedures into operational activities (Hofmann, Burke & Zohar 2017), and make choices about how and which interventions to implement (Zohar 2008).

Similarly, supervisors are known to provide the most relevant source of rewards and support (Luthans & Kreitner 1985). They execute procedures by turning them into context-specific action instructions (Zohar 2000). When workers perceive that their supervisors support the enactment of HSIs, such as BBS programs, the intervention tends to be more effective (Zhang et al. 2017). In most cases, supervisors can rightfully apply formal sanctions to enforce role expectations (Dienesch & Liden 1986). As a result, they are likely to serve as a source of more information and support for new workers (Feldman & Brett 1983). These arguments imply that a favourable supervisory environment is positively related to human safety interventions.

5.3.5 Supervisory environment has a positive relationship with workgroup safety climate

The study suggested that supervisory environment would be positively related to workgroup safety climate. This implies that a favourable supervisory environment would improve workers perceptions' about the value of safety. This proposition was supported, as shown in Table 4.22. Traditionally, supervisors have frequent interactions with workers, and their responses to safety are important cues for workers to determine the priority and value of safety practised in their workgroups (Cheung & Zhang 2020; Fang, Wu & Wu 2015; Zhang, Lingard & Nevin 2015). Hence, when supervisors convey safety as a top priority, workers will also infer the same. Based on social information processing (Salancik & Pfeffer 1978) with social learning (Bandura & Walters 1977), which postulates that individuals' attitudes and behaviour are affected by social cues in their close social environment, supervisors can communicate the value of safety throughout the workgroup (Kessler et al. 2020). As such, how supervisors lead, and the environment they create for safety to thrive, shape the perceptions workers form about how the organisation supports and rewards safety.

In the same way, the behaviour of supervisors, such as listening and providing feedback, affect the climate (Mack, Nelson & Quick 1998). More specifically, such behaviour is related to both group safety climate strength and level (Zohar & Luria 2004).

This presents supervisory practices as amongst the more significant predictors of workgroups proclivity to execute safety initiatives (Simard & Marchand 1997). Likewise, supervisor characteristics predict safety climate perceptions (Schwatka, Hecker & Goldenhar 2016). The current group safety climate is therefore linked to the patterns of supervisory safety practices (Zohar 2000). Through the principle of least effort, the supervisory environment informs workers of the relative value of safety when considering other conflicting needs, such as safety versus productivity (cf. Ashforth 1985; Zohar 2003). This enables the emergence of shared perceptions within the workgroup. Considering these, the supervisory environment has a significant positive relationship with workgroup safety climate (cf. Zohar & Luria 2004).

Considering personal differences in supervisors such as personality and values, some supervisors may implement the company's rules and procedures differently from others, hence communicating diverse levels of climate to their workers (Luria 2015). For example, consider a construction site where the safety supervisor for building A engages workers in regular safety talks, whereas the supervisor for building B often advocates working around safety procedures to meet important deadlines. Through social exchanges, workers in building A are expected to have a positive perception about the current state of safety on the site, whereas workers in building B are likely to assign more priority to meet work demands such as finishing works on time, at the expense of safety. Even in the same building, two supervisors may still send conflicting signals. This can be challenging for workers as such contradicting pieces of information creates gaps between espousals and enactments (Zohar & Hofmann 2012). That is while the written policies and declarations mention that safety is paramount, the daily practices compromise safety to improve work demands (Paté-Cornell 1990). Workers then make sense of this conflicting information, deduce a pattern from all such incidents and decide the true priority of safety (Luria 2015; Weick 1993). In consequence, supervisors must place a higher value on safety to make workers view safety as a top priority. In sum, supervisors play a significant role in influencing safety climate (Zohar 2010).

5.3.6 Human safety interventions have a positive relationship with workgroup safety climate

The study suggested that HSIs would be positively related to workgroup safety climate. This means that effective implementation of human safety interventions would improve workgroup safety perceptions. This hypothesis was empirically supported by the statistical analysis. Safety interventions influence the formation of a positive workgroup safety climate (Cheung & Zhang 2020), suggesting that these interventions could improve safety climate (Huang, Chen & Grosch 2010). This is consistent with the social exchange theory, in which, when an organisation is thought to fulfil their duties, care for workers fairly, and offer valued services and benefits, workers reciprocate with higher levels of commitment and performance (Mearns et al. 2010). For instance, when an organisation provides their workers with adequate safety training (HSI_1) and programs designed to influence their actions toward maintaining safe workplace (HSI_9), the workers give back by performing good safety behaviours. Because the organisation offering career development might expect that workers benefiting from such opportunities will acknowledge an obligation to provide the organisation with a considerable payback in the future (Dabos & Rousseau 2004). Specifically, this psychological contract is shaped by an individual's experiences in the organisation (Rousseau 1995).

From these mutual exchanges, when a party's contributions produce a disparity in the relationship, the indebted party feels obligated to the other and seeks to give back as a way to re-establishing the balance (Eisenberger et al. 2001). For example, when an organisation frequently organises toolbox meetings for workers (HSI_2) and provides workers with safety awareness programs (HSI_8), they reciprocate by having positive perceptions about the value management places on safety, which would then lead to positive safety behaviours. Similarly, when management provides human safety interventions such as offering safety incentives to workers for working safely (HSI_10) and encouraging workers to get involved in safety campaigns (HSI_4), it reinforces their views on the priority of safety within their workgroup. On the other hand, if the organisation does not always fulfil their safety obligations, workers may perceive this as a violation of the contract, which could lead to unsatisfactory safe work behaviour (Newaz et al. 2019b).

However, the level at which the climate operates defines the kind of intervention that should be designed (Kessler et al. 2020). Safety interventions are rarely implemented at the managerial level (McDonald & Hrymak 2002). Earlier discussions and conceptualisations in this study suggest that the HSIs affect the workgroup. This is particularly important because the workgroup safety climate is part of the group climate, where both workers and supervisors co-exist. Moreover, as Luria (2019, p. 1055) observes, “climate is a group-level phenomenon that should be measured and studied at the group level”. Hence while managers offer theoretical grounds for designing interventions, supervisors are responsible for translating them into tangible practices (Kessler et al. 2020). In view of these discussions, it appears that HSIs are positively related to workgroup safety climate, since the formation of a positive workgroup safety climate involves effort and safety-related interventions (Cheung & Zhang 2020). Hence, HSIs could succeed in improving safety climate (cf. Clarke 2010).

5.3.7 Human safety interventions mediate the relationship between supervisory environment and workgroup safety climate

The study confirmed positive relationships between supervisory environment and HSIs, as well as HSIs and workgroup safety climate. This section proposes that the association between supervisory environment and workgroup safety climate is further mediated by HSIs. The analysis provides support for the hypothesis that, HSIs partially mediate the association between supervisory environment and workgroup safety climate. These results suggest that while a direct link between supervisory environment and workgroup safety climate is acknowledged, this relationship is not straightforward. Although supervisors have been known to influence workgroup safety climate through social learning, leader-member exchanges, and social information processing, among others, this effect works well through the implementation of tangible programs and practices such as HSIs.

At the group level, this phenomenon could be explained through social learning theory (Bandura & Walters 1977). From social learning, workers observe and practice the type of behaviour that is recognised, supported, and rewarded by their supervisor, and, as such, supervisor characteristics are viewed as antecedents to safety climate perceptions (Dragoni 2005; Lingard, Cooke & Blismas 2009; Schwatka, Hecker & Goldenhar 2016; Zohar 2000). The quality of leader-member interactions plays a vital part in the development of safety climate (Zohar et al. 2014). These exchanges between these agents are characterised by trust, respect, identification, and mutual obligation (Huang et al. 2021). Employees in high-quality leader-member interactions reciprocate to their leaders by involving in discretionary behaviours that benefit the leader and others at the workplace (Liden, Sparrowe & Wayne 1997). Besides, social information processing suggests that attitudes at the workplace are a result of both personal perceptions and that of the immediate social environment (Salancik & Pfeffer 1978). Considering the nature of construction sites, workers depend on their individual perceptions as well as on social cues to understand the situation. Within this social context are safety agents such as supervisors and co-workers, each playing a crucial role in the application of HSIs such as safety campaigns (HSI_4) and training (HSI_1).

Gatekeeping is a term introduced by Zohar & Luria (2010) to depict how leaders (e.g. in a group or supervisory role) interpret events to group members or subordinates. While sensemaking involves the methodical processing of information in the surrounding to assign and gain meaning from it (Luria 2019). Through gatekeeping and sensemaking, supervisors communicate and interpret organisational priorities to workers (Hofmann, Burke & Zohar 2017). For example, supervisors act as gatekeepers interpreting the meaning of organisational occurrences to workers (Zohar & Luria 2010). In times where organisational priorities seem detrimental to workers, transformational supervisors prioritise workers safety by modifying the formally espoused organisational priorities (Zohar & Luria 2010). This situation should improve workgroup safety climate. Also, workers attempt to make sense of complex and contradictory work scenarios by engaging in social exchanges (Weick 1995; Zohar 2010). This means that frequent interactions among workers and with their supervisors will lead to shared appraisals, hence a stronger climate (Rentsch 1990). For example, sociological safety interventions such as safety training (HSI_1), toolbox meetings (HSI_2), and safety campaigns (HSI_4) offer mediums for sharing and clarifying perceptions, therefore augmenting safety climate.

It is crucial for supervisors to “walk the talk”, and not doing so leads workers to view supervisors as hypocritical or as simply “paying lip service” to safety issues (Clarke 2013, p. 35). “Walking the talk” implies that, supervisors should model desired behaviours themselves for workers to emulate. “Walking the talk” could be done through the implementation of safety interventions such as HSIs. Hence, this enforcement, which is usually a function of supervisors, is an important element of safety climate and makes supervisors appear more genuine when they are involved in what they enforce (Kessler et al. 2020). For example, most of the HSIs require the involvement of the immediate supervisors, thereby implying multiple mediums for symbolic interactions, sensemaking and social learning as workers frequently engage with supervisors. As Rentsch notes, “The basic sensemaking process involves observing organisational events, detecting or abstracting patterns of relationship among the events, and interpreting these events in psychologically meaningful terms” (Rentsch 1990, p. 669). For example, although the espoused safety rules and procedures suggest the need to work safely even in demanding times, yet supervisors themselves do not follow these regulations but rather champion higher productivity in the quest to get the work done at the detriment of safety. Workers make meaning out of such contradictory events by deducing a pattern, have a shared understanding with each other using social construction processes such as short narratives, then reach conclusions about the relative importance of each facet at the workplace (Luria 2019; Volkema, Farquhar & Bergmann 1996).

New co-workers also become socialised into the organisation through such interventions while gaining an understanding of the organisation’s rules, practices, and procedures, among others (cf. Jones 1983; Katz 1980; Louis 1980). They accept rules or norms of behaviour and the desire for group cohesion by norming their behaviours. At the norming stage of team development, new co-workers adopt behaviours that meet the goals of the team (Elwyn, Greenhalgh & Macfarlane 2001). Due to these consensual experiences, group safety climates are expected to be higher as relationships become stable and confusing signals fade. Supervisors can contribute to strengthening the norming phase by adopting good people skills such as effective communication and collaboration. From these processes, the salient social cues triggered through HSIs such as safety campaigns and toolbox meetings help workers to understand the importance of safety within their groups and organisation. In summary, HSIs provide the opportunity for member-supervisor cooperation and communication, which improves group cohesion and perceptions of safety priorities (cf. Turner & Parker 2004). From these discussions, the supervisory environment is shown to positively influence the workgroup safety climate through the HSIs.

5.3.8 Human safety interventions moderate the relationship between supervisory environment and workgroup safety climate

The study also proposed that the relationship between supervisory environment and workgroup safety climate is strengthened when HSIs are implemented. This hypothesis was supported as shown in Table 4.22 and Figure 4.9. This hypothesis is based on similar earlier discussions, but through role (Katz & Kahn 1978) and organisational support (Eisenberger et al. 1986) views. Roles imply that people play a part in an assigned working relationship (Katz & Kahn 1978), and, as such, roles are defined as prospective behaviour that is to be carried out with a particular job (Shivers-Blackwell 2004).

One role for supervisors is to make decisions about how and which interventions to implement (Zohar 2008). This safety role is therefore an expectation of supervisors, linking the supervisor to the organisation, and vice versa (Schuler, Aldag & Brief 1977). Hence, when supervisory roles are clarified in terms of HSI enforcement, their safety roles become affirmed and the influence that supervisors have on workers' perceptions of the value of safety tends to increase. Further, as Kessler et al. observe, "supervisors cannot rely upon communicating the importance of safety through words alone" (Kessler et al.

2020, p. 451) because the fundamental measurement of behaviour is an act (Dougherty & Pritchard 1985; Naylor, Pritchard & Ilgen 1980). As a result, ambiguous roles are dysfunctional for both the individual and their organisation (Jackson & Schuler 1985; Kahn et al. 1964). Managers should therefore make efforts to eliminate ambiguity from work situations (Martinko 2002) since they can instruct supervisors (Yukl 2004) while providing the theoretical grounds for designing interventions (Kessler et al. 2020). According to this line of reasoning, the implementation of HSIs by supervisors strengthens the influence that the supervisory environment has on workgroup safety climate as they continue to perform their roles.

From another view, perceived organisational support suggests that perceptions of supervisor' support have a great impact on workers' perceptions of organisational support (Shanock & Eisenberger 2006). For this reason, through reciprocity, supervisors feel obliged to help the organisation when they feel supported by the organisation. This consideration to help the organisation is further extended to subordinates. For example, when supervisors perceived that they were fairly supported/treated by their organisation, they reciprocated by treating workers more favourably (Masterson 2001; Tepper & Taylor 2003).

Likewise, this organisational support could also emerge from the implementation of safety interventions that are mandated by the organisation. As such, management expectations of HSIs communicated to supervisors will influence the supervisory practice (see Bacharach, Bamberger & Sonnenstuhl 1996). Therefore, a cohesive managerial proposition exists whereby more consistent and visible supervisory practices facilitate the development of consensual climate perceptions (Zohar & Luria 2004). Considering this, the relationship between supervisory environment and workgroup safety climate is positively strengthened when there is an increase in the implementation of HSIs.

5.3.9 Workgroup safety climate has a positive relationship with co-workers' safety behaviour

The study suggested that workgroup safety climate would be positively related to co-workers' safety behaviour. This hypothesis was empirically supported, as shown in Table 4.22. Evidence from meta-analytic reviews shows that positive safety climates are positively correlated with increased levels of safety behaviour (cf. Alruqi, Hallowell & Techera 2018; Christian et al. 2009; Nahrgang, Morgeson & Hofmann 2011). However, discussions in the literature indicate that this evidence is mostly at the individual and organisational level, while far fewer studies have documented that of the group level in construction. This could be explained by the social exchange theory (Blau 1960).

According to social exchange theory, when individuals perceive that their organisation values their welfare, they will cultivate an inherent commitment to give back by exhibiting behaviour that benefits their organisation (Neal & Griffin 2006). These exchanges operate on the principles of reciprocity (Cropanzano & Mitchell 2005). This framework of social exchange provides the quid pro quo among agents within an organisation as it forms a norm of reciprocity which in turn breeds desired behaviour. The workgroup safety climate assumes that there is a group process of climate emergence that is shared within the group (cf. Luria 2019). This workgroup climate, which is a higher-order social context, is key to explaining employee responses, behaviour, and performance (Fulmer & Ostroff 2016; McEvily, Soda & Tortoriello 2014).

Within a workgroup, there is interdependence among members which is developed in the formation of climate process (Luria 2019). This emergence characteristic is an attribute of climate (Ostroff, Kinicki & Muhammad 2012; Zohar & Hofmann 2012). In this view, the whole is more than the sum of the parts (Ablowitz 1939). This emergence attribute further leads to the development and understanding of climate at the group-level. Through social information processing, one's perceptions and the immediate social context (including co-workers) affect attitudes at work (Salancik & Pfeffer 1978). Also, through symbolic interactions, the relationships among people produce meaning (Luria 2019). This meaning is a condition that emerges from the interactions among members of a group (Blumer 1969). These meanings are known to influence the perceptions that workers form about events in their work environment. Further, through collective sensemaking, group members do not just view organisational experiences as predicted by individual patterns of perception and cognition, but also as affected by their immediate colleagues (Gioia et al. 1994).

According to the aforementioned theories (Luria 2019), and related ones such as sensegiving (Gioia & Chittipeddi 1991), event cycles (Morgeson & Hofmann 1999), homophily (Festinger 1957) and classic balance (Heider 1946), group members tend to produce shared perceptions about the priority of safety within their organisation. Hence, this homogeneity in perceptions is realised through the exposure to events, interpretation of events, and preservation of perceptions (Luria 2019). Through frequent interactions among workers in a group, individuals develop beliefs about what is desired at the workplace. From this view, co-workers are not just a crucial component of the social setting at the workplace, they actually define it (Schneider 1987).

Notably, co-workers provide information and interact in conduct validation for some activities while deterring others, helping to mould a co-worker's dogmas about the "do's and don'ts" (Chiaburu & Harrison 2008; Ilgen & Hollenbeck 1991). From the discussions, it appears that when an employee in a group behaves unsafely, which may be undesirable to the group, the group will most probably react negatively (Luria 2019). This implies that, when there is a favourable workgroup safety climate, co-workers would reciprocate by behaving safely.

5.3.10 Human safety interventions moderate the relationship between workgroup safety climate and co-workers' safety behaviour

The study also proposed that human safety interventions would moderate the relationship between workgroup safety climate and co-workers' safety behaviour. This hypothesis was supported, as shown in Table 4.22 and Figure 4.8. A positive increase in HSIs is expected to improve the relationship between the two constructs. This could be reasoned in line with discussions in Sections 5.3.6 and 5.3.9, because while workgroup safety climate is acknowledged as a predictor of co-workers' safety behaviour, this relationship is strengthened by HSIs. HSIs offer opportunities for workers to have multiple social interactions (e.g., during safety campaigns) with others and their immediate social environment. These interventions, which are implemented at the group level, influence the perceptions that co-workers have about the priority of safety in the organisation.

It is expected that through symbolic interactions, sensemaking, and social learning, among others, an increase in HSIs would improve the workgroup safety climate (see Section 5.3.6). This implies that HSIs provide fertile ground for developing the climate process within workgroups, and further reinforcing earlier assertions about climate formation. HSIs thus create, as Luria argues, "an environment in which group members are exposed repeatedly to events and interpretations that strengthen the existing climate" (Luria 2019, p. 1059). These events are the daily occurrences at the workplace such as safety practices, toolbox meetings, wearing of PPE, individual experiences, or the work itself, while the interpretations are the meanings workers give to the events. The events experienced by each employee derive their interpretations from interacting with other group members (Luria 2019). As conceptualised, when workers' perceptions of the priority of safety become more consensual and shared among co-workers, they reciprocate with desired safety behaviour (cf. Zohar & Tenne-Gazit 2008). Therefore, HSIs strengthen the relationship between workgroup safety climate and co-workers' safety behaviour.

5.3.11 Human safety interventions have a positive relationship with co-workers' safety behaviour

The study proposed that HSIs would be positively related to co-workers' safety behaviour. This hypothesis was rejected, as shown in Table 4.22. The results suggest that although the association between the two variables was positive, this link was not significant. This means that HSIs do not directly influence co-workers' safety behaviour, but influence co-workers' safety behaviour through workgroup safety climate (see Figure 4.7). As previously discussed in Section 5.3.10, HSIs act as effect-modifying variables (Robson et al. 2001), contributing to the climate-behaviour-accident model.

Considering the stages of group-level climate emergence, that is, exposure to events, interpretation of events, and preservation of perceptions (Luria 2019), avenues for social interactions are prerequisites for developing uniformity in the group cognition of safety events. Workers would have to be exposed to HSIs, then exercise sensegiving and interpret these HSIs through social information processing, symbolic interactions, and sensemaking. Then through, event cycles, homophily, balance theory and similarity attraction, the workers preserve their perceptions. According to Luria (2019), these stages encourage and sustain a group climate. Therefore, as Zohar & Luria-Gazit argue, “the greater the consensus, the stronger the climate” (Zohar & Tenne-Gazit 2008, p. 745). This reiterates the earlier findings of this study, that HSIs do not significantly influence co-workers’ safety behaviour; however, an increase in HSIs would strengthen the relationship between workgroup safety climate and co-workers’ safety behaviour.

5.3.12 Co-workers’ safety behaviour mediates the relationship between workgroup safety climate and co-workers’ safety outcomes

The study suggested that co-workers’ safety behaviour would mediate the relationship between workgroup safety climate and co-workers’ safety outcomes. This hypothesis was supported, as presented in Table 4.22. From expectancy valence, workers will be motivated to adhere to safety procedures and partake in safety actions if they perceive that this behaviour will lead to valued outcomes (Neal & Griffin 2006; Zohar 2000). Expectancy suggests that the effort towards a certain behaviour will lead to that behaviour (Andriessen 1978; Waring 2015), whereas valence is the rewards or relevant outcomes for that behaviour. Hence, valence is subjective, or the degree to which these outcomes are valued by the individual (Ford & Tetrick 2008; Lingard & Rowlinson 1998). Instrumentality denotes the employee’s belief of attaining the reward/valence as assured by the management (Hon, Chan & Yam 2014; Vroom 1964). To this end, the rate and intensity with which an organisation observes and acts on safety matters define the expectancy valence related to safe or unsafe behaviour (Zohar 2000).

As a result, while favourable safety climates are associated with increased levels of safety performance/safety behaviour (Alruqi, Hallowell & Techera 2018; Beus et al. 2010; Christian et al. 2009; Lingard, Cooke & Blismas 2010a; Nahrgang, Morgeson & Hofmann 2011), this relationship works though safety behaviour, because safety climate informs behaviour-outcome expectancies (Beus et al. 2010; Zohar 2014; Zohar & Luria 2003). For example, when workers become aware that their organisation values productivity over safety, they are less likely to behave safely, since they are influenced by their organisation to maximise productivity (Morrow et al. 2010) and then through behavioural biases, such as melioration, rare-events, and social externalities, they underweight outcomes. As such, unsafe behaviour will result in an accident (Reason 1990). Therefore, as Beus et al. observe, since "safety climate informs behaviour-outcome expectancies, a supportive safety climate, in which safe behaviour is reinforced, is expected to be associated with fewer injuries" (Beus et al. 2010, p. 714).

Safety climate is considered to be a primary source of safety-related behaviour-outcome expectancies (Schneider 1975; Zohar 2011). Owing to these discussions, and the empirical support, positive workgroup safety climates are significantly linked with co-workers' safety behaviour, which leads to the reduction in safety outcomes such as accidents/injuries and near misses.

5.3.13 Co-workers' safety behaviour has a negative relationship with co-workers' safety outcomes

The study proposed that co-workers' safety behaviour would be negatively related to co-workers' safety outcomes. This suggests that in the circumstance where co-workers' safety behaviour is admirable, there would be a reduction in the co-workers' safety outcomes such as accidents/injuries and near misses. This hypothesis was empirically supported, as shown in the previous chapter. Discussions in Section 5.3.12 stress the role that safety behaviour plays in reducing accidents/injuries. Considering the proximal nature of working relationships on construction sites, social interactions among employees are highly likely to occur. As a result, social cues generated from other co-workers are expected to influence other members of the group through social learning and social information processing.

From this view, when co-workers consistently exhibit unsafe behaviour, which may be admirable to the group, other workers reciprocate in the same manner. Therefore, through frequent interactions between co-workers, individuals develop their beliefs about what is expected in the work environment (Chiaburu & Harrison 2008). When these interactions among co-workers are positive, an increase in workers' job performance is likely to occur (Chen, Takeuchi & Shum 2013). This is important, as safer workplace behaviour is a predictor of safety outcomes such as accident occurrences (cf. Beus, McCord & Zohar 2016; Cooper et al. 1994; Neal & Griffin 2006). Considering these discussions and earlier comments in Section 5.3.12, positive co-workers' safety behaviour would result in a reduction in co-workers' safety outcomes such as accidents/injuries and near misses.

5.3.14 Co-workers' safety outcomes have a negative relationship with workgroup safety climate

The study proposed that co-workers' safety outcomes would be negatively related to workgroup safety climate. Table 4.22 provides empirical evidence for this hypothesis. Injuries have been considered as an antecedent of safety climate, since they provide information about the workplace (Beus et al. 2010). This is because when injuries occur they are indications of the fundamental safety climate in an organisation (cf. Spence 1973). This line of reasoning denotes that workers' observations of previous injury-related occurrences and experiences will affect their views of safety practices, procedures, and policies (Schneider & Reichers 1983). This is based on the perspective that the outcomes of climate perceptions can, in turn, serve as predictors of climate (Schneider et al. 2017; Schneider, White & Paul 1998).

Similarly, whereas empirical evidence shows the influence of safety climate on accident occurrence at the group level (cf. Andersen et al. 2018), the possible reciprocity of how this occurrence influences workers' perceptions concerning safety as an organisational priority at the workgroup level is unclear. Owing to this, meta-analytic evidence shows that injuries are predictive of organisational-level safety climate (Beus et al. 2010), suggesting that, while "injuries could be conceptualised as antecedents of safety climate perceptions" (Beus, McCord & Zohar 2016, p. 367), the majority of this evidence is at the organisational level. Accidents are considered to be harmful and disruptive, hence they can impact organisational learning (Beus, McCord & Zohar 2016).

According to the symbolic interaction theory, workers in a group interpret events to determine the importance of a climate (Luria 2019). When accidents occur, they happen to co-workers within the work environment. These incidents take place within physical and social proximities to the workgroup. By such means, accidents depict a lack of safety (Beus, McCord & Zohar 2016). The frequent occurrence of accidents informs and affects workers' interpretations of the prevailing conditions regarding how the organisation values safety, thereby weakening the perceptions that workers form about the priority of safety (Bergman et al. 2014; Beus et al. 2010). Thus, accidents and injuries are symbolic of the inherent safety climate in the organisation (Spence 1973). To this end, when there is an increase in co-workers' safety outcomes, such as accidents/injuries and near misses, the workgroup perceives safety as a low priority in the organisation.

5.4 Route to Curbing Poor Safety Outcomes

In this section, the study highlights an interesting route (Figure 4.7) to reducing accidents/injuries and near misses. It suggests a logical approach to tackling poor safety outcomes. This path flows from management commitment → current safety rules and procedures → management communication → supervisory environment → human safety interventions → workgroup safety climate → co-workers' safety behaviour → accidents/injuries and near misses. Each relationship between individual variables is comprehensively explained in Sections 5.3. To minimise poor safety outcomes, the path suggests that, at the beginning of a construction project, management must show their commitment by creating safety rules and procedures that are effective and practicable for workers to comply with. This can be done by involving workers during the development of these rules and regulations, which then increases their safety citizenship behaviour. After establishing the effective rules and procedures, management should communicate them to workers through mediums such as supervisors, safety awareness programs, face-to-face meetings, virtual reality technologies, operating open-door policies, toolbox meetings, and persuasion.

Next, the expectations communicated by management would influence supervisory practice. Through principles of mutuality, reciprocity, and roles, when management assigns a high priority to safety, supervisors reciprocate by being more concerned about safety matters. Considering the daily micro-decisions that supervisors make in enforcing organisational policies and procedures, a favourable supervisory environment would facilitate the implementation of HSIs. Once HSIs, e.g., safety campaigns, toolbox meetings, safety bulletin boards, are implemented, they offer opportunities for the development and improvement of climate perceptions. This works because HSIs provide the grounds for social interactions, mutual obligations, sensemaking, and reciprocity, which are known to contribute to the processes of climate emergence.

After HSIs provide a suitable platform for the formation of climate perceptions in the workgroup, these perceptions would then affect the safety behaviour of co-workers through social exchanges. For example, when management is committed to safety, communicates safety rules and procedures effectively, and provides supportive environment, workers reciprocate by ensuring the highest levels of safety when they carry out their job (SafCom_3) and put in extra effort to improve the safety of the workplace (SafPart_2). Workgroup safety climate, therefore, influences participation and compliance behaviours. Finally, an increase in co-workers' safety behaviour decreases poor safety outcomes. Because, when frequent interactions occur between workers, they develop their perception of what is expected at the workplace. When these perceptions are positive, poor safety outcomes are likely to reduce. Hence, the introduction of HSIs such as easy access to safety information, adequate supervision on site, safety incentives, and safety campaigns provides a suitable avenue for generating positive psychosocial interactions within the workgroup, which goes a long way in curbing accident/injuries and near misses.

5.5 Chapter Summary

This chapter discussed the findings of the study. It provided the theoretical explanations for the empirical results presented in Chapter Four. The two factors generated from the previous chapter were conceptualised as psychological safety interventions and sociological safety interventions. The two factors were considered as reflective-reflective higher-order constructs due to their mutuality in explaining various events. The study defined psychological safety interventions as methods that change workers' perceptions of safety practices, risks, and uncertainties whereas sociological safety interventions are safety practices that improve workers' knowledge and reasoning concerning safety through socially related activities at work.

One out of the fourteen hypotheses was rejected. HSIs do not directly influence co-workers' safety behaviour. Instead, an increase in HSIs strengthens the relationship between how workers' perceived the value of safety and co-workers' safety behaviour. Through social exchanges, the provision of HSIs positively improves workgroup safety climate. The relationship between supervisory environment and workgroup safety climate was strengthened by HSIs. While supervisory environment is acknowledged to affect workgroup safety climate, this relationship is not straightforward, because it is through the effective implementation of HSIs that supervisory environment impacts workers perceptions. An increase in safety outcomes was found to decrease the workgroup safety climate. The study also identified a route to reducing the number of accidents/injuries and near-misses on construction sites. The next chapter concludes the study, highlights its limitations, and provides recommendations for further study.

6 CONCLUSIONS

6.1 Introduction

The study sought to investigate the role of human safety interventions (HSIs) on the impact of workgroup safety climate on co-workers' safety behaviour. The objectives set in achieving this goal are reviewed in this chapter. The chapter also highlights the contributions and limitations of the study. Future research needs are also suggested.

6.2 Review of Research Objectives

Five objectives were established for answering the question, "how do HSIs influence the impact of workgroup safety climate on co-workers safety behaviour in construction projects?" How each objective was addressed, and the resulting key findings are presented hereafter.

6.2.1 Review literature linked with the key concepts of safety climate, safety behaviour, and safety outcomes

This first objective was addressed in Chapter Two. The goal was to unearth the underlying foundations of safety climate, safety behaviour, and safety outcomes. This was to further understand the mechanisms through which these variables interact. Discussions of agents pertinent to safety climate on construction sites were also presented. Considering the multilevel nature of safety climate, the review identified the appropriate levels needed to capture construction workers' safety perceptions. The dimensions of safety climate were operationalised to determine the level at which each functioned. Theoretical differences were provided for both safety behaviour and safety outcomes. Various approaches required to measure these constructs were also appraised to identify ideal assessment tools. Where relevant, the literature was problematised or critiqued.

The review found that the focus on safety climate as an organisational and social factor can be used to address the hearts and minds of workers and their leaders in the quest to improve safety behaviour and, consequently, to minimise accidents on construction sites. It was also established that, through symbolic interactions, workers develop consensual and shared perceptions about the priority of safety within their organisation. The importance of understanding these perceptions is that they influence safety outcomes. The literature review suggested that, due to the hierarchical nature of construction organisations and projects, safety climate ought to be investigated at multiple levels. Because workers' perceptions are moulded at varying levels within the organisation, this study focused on group and organisational levels. Nevertheless, most of the existing safety climate studies have focused on one unit of analysis, typically the organisational.

Based on the idea that co-workers comprise the workplace, it was essential to focus on the workgroup, as is a more appropriate unit of analysis. Despite the superior influence of co-workers on other workers, the review indicated that the causal influences among this group of agents within the safety climate field are not well understood in construction. Few empirical studies have explored the emergence of worker-to-worker safety perceptions, as most research has focused on leader-to-worker exchanges. Also, the referent-shift approach was determined as a more robust technique for aggregating workers safety perceptions during assessments, and hence it was adopted in this study. Unfortunately, the review indicated that numerous safety climate studies have too often used the direct-consensus approach, which is known to have several limitations.

Considering the inconsistencies and debates surrounding the dimensions of safety climate, the review identified a validated questionnaire with ten associated dimensions relevant to the Australian construction industry. After theorisations, a framework (Figure 2.1) was developed to capture the dimensions that suited a level of climate analysis. This framework was important to the study to avoid unit level discrepancies between theory and measurement units (Zohar 2000, 2010). Safety behaviour was also identified as a predictor of safety outcomes. From the review, most empirical studies adopted safety behaviour as the measure of safety performance; however, it is more appropriate to consider both leading and lagging indicators to provide a valid and reliable measure of safety performance. This led to the inclusion of the accidents/injuries and near misses scale. Finally, social exchange theory and expectancy-valence theory was used to explain the linkages between safety climate, safety behaviour, and safety outcomes. This objective further contributed to objective two by highlighting possible causal inferences relevant to hypothesis development.

6.2.2 Create a theoretical model of the role of HSIs on the impact of workgroup safety climate on co-workers' safety behaviour

This second objective was addressed in Chapter Two. This objective proposed a theoretical model based on conceptualisations the literature. Considering that the climate-behaviour-accident route is not straightforward, as is often presumed (Cooper & Phillips 2004), this objective sought to answer the numerous unanswered calls to determine safety interventions relevant for improving safety climate perceptions. Two key features of the construction industry were used in selecting HSI as the appropriate intervention. Linkages between variables that constituted the construct of HSIs were also discussed. Thirteen hypotheses were proposed in the quest to minimise co-workers' poor safety outcomes, such as accidents/injuries and near misses. Finally, considering the complexity of the study's theoretical model, another model was developed, as it was statistically impossible to estimate the relationship using the main proposed framework. The associated hypothesis was based on the view that outcomes of climate perceptions can in turn serve as antecedents of climate (Schneider et al. 2017). In all, fourteen hypotheses were proposed for analysis.

Based on the social exchange and resource theories, the objective determined the relevance of HSIs to the climate-behaviour-outcome fraternity. Borrowing insights from the Hofstede model and Prospect theory, national culture and decision making under risk and uncertainty were considered in selecting HSIs. The discussions of the linkages among the variables that constituted the construct of HSIs indicated mutuality in explaining safety events. The study also suggested that an increase in management commitment would improve the current safety rules and procedures. Once the current safety rules and procedures are implemented, management can communicate them to workers. This means that an increase in management communication in the form of mutual obligations, assigning a high priority to safety, and clarity in role specification would lead to a favourable supervisory environment. This positive supervisory environment will ensure the success of HSI implementation while affecting the workgroup safety climate. The HSIs are also likely to influence the workgroup safety climate. From these assumptions, HSIs may play both mediating and moderating roles between supervisory environment and workgroup safety climate. For example, when supervisors support and implement HSIs such as safety campaigns, safety training, toolbox meetings, and adequate safety supervision, workers tend to see supervisors as genuine since they are involved in what they enforce. This phenomenon generates good social cues among the workers, leading to the formation of ideal safety perceptions by assigning substantial value to safety in the face of competing demands such as productivity. Thus, the implementation of HSIs by supervisors further reinforces their role as gatekeepers in interpreting organisational priorities.

On the other hand, a positive workgroup safety climate could result in good co-workers' safety behaviour. HSIs may also be positively related to co-workers' safety behaviour. Considering these, it was anticipated that HSIs would strengthen the relationship between workgroup safety climate and co-workers' safety behaviour. This could mean that good co-workers' safety behaviour will cause a reduction in co-workers' safety outcomes such as accidents/injuries and near misses. These suggestions imply that workgroup safety climate would influence co-workers' safety behaviour, which would in turn lead to fewer co-worker safety outcomes. Naturally, an increase in co-workers' safety behaviour will lead to accident reduction. While the effect of safety climate on safety outcomes is established, the reverse causality at the group level lacks empirical evidence. Hence, this relationship was also proposed. This objective led to objective three, which focuses on building and validating the HSI construct before integrating it into the research model for statistical analysis.

6.2.3 Develop and validate the construct of HSIs

This third objective was addressed in Chapter Four. The goal was to develop a reliable measure for measuring HSIs. Zaira & Hadikusumo (2017) developed a preliminary questionnaire for the Malaysian construction industry. Their measure comprised eleven items that were rated using a three-point Likert scale. However, some key improvements could be added to the questionnaire to ensure high explanatory and predictive power, especially within the Australian context. To do this, a pilot study was conducted with a group of experts, which consisted of a statistician and construction, and safety academics. The items were measured on a five-point Likert scale ranging from 1=strongly disagree to 5=strongly agree. Feedback from the experts resulted in restructuring of the items in terms of their clarity, framing, theoretical considerations, and suitability for the construction industry.

Stand-alone phrases/terminologies were placed in sentences to indicate their directional impact. Overlapping content and the use of multiple terminologies to describe similar concepts, such as "safety awareness program, safety campaigns, safety knowledge program, safety education" were streamlined to eliminate ambiguity. The item "penalty, accident repeater punishment programme" was deleted due to its inapplicability and inappropriateness for the Australian construction industry. After the process and final review by the experts, twelve items were developed. During the main study, a valid sample of 297 construction trade workers indicated their responses about how well their co-workers were provided with HSIs by their employer. The data were subjected to exploratory factor analysis, normality tests, reliability analysis, and confirmatory factor analysis. After the computations and evaluations, the scale was deemed psychometrically sound, with good fit and validity.

This resulted in two factors with three items under each. The factors were named psychological safety interventions and sociological safety interventions. The analysis revealed about 20% overlap between the two factors. This is important because well-driven interventions to augment safety that do not consider a wider array of interrelating social-psychological aspects may fail or even be counter-productive (Törner 2011). Also, the interplay offers opportunities for cross-fertilisation by considering contextual and structural constraints associated with a unidimensional view when offering insights on safety events. This suggests that the two factors should be regarded as reflective-

reflective higher-order constructs, because they tap into the same underlying concept or phenomenon (Chin 1998).

The study defined psychological safety interventions as methods for altering workers' perceptions of safety practices, risks, and uncertainties. This construct is guided by learning behaviour, prospect, and social exchange theories. On the other hand, sociological safety interventions are safety practices that improve workers' knowledge and reasoning concerning safety through socially related activities at work. This construct dwells on symbolic interactions by following the sociological theory of industrial accidents, which posits that, "industrial accidents are produced by social relations of work" (Dwyer & Raftery 1991). The validated HSIs scale could be used for monitoring and diagnosis of potential weaknesses in safety practices. It also could be examined with other established constructs as mediators, moderators, and antecedents to form a route towards cultivating desired behaviour. For the next objective, the validated HSI construct, along with the hypotheses in objective two, were examined to confirm the validity of the theoretical models.

6.2.4 Examine the role of HSIs on influencing the relationship between workgroup safety climate and co-workers' safety outcomes

This fourth objective was addressed in Chapter Four. Considering the complexities and nature of constructs, partial least squares-structural equation modelling (PLS-SEM) was used to analyse the 297 valid cases in the quest to evaluate the conceptual model and validate the theoretical assumptions discussed in objective two. These assessments were performed to empirically provide evidence on the role of HSIs in influencing the association between workgroup safety climate and co-workers' safety outcomes. The initial measurement model was specified by considering the nature of the constructs and relationships. The repeated indicators approach was used in specifying higher-order constructs such as workgroup safety climate and HSI.

The initial measurement model satisfied all the requirements for internal reliability and discriminant validity. However, an item, "It is not acceptable to delay periodic inspection of plant and equipment", did not attain acceptable item reliability. Also, convergent validity was not established for two constructs, "Appraisal of the physical work environment and work hazards" and "Co-worker appreciation of risk". A final measurement model was estimated after dropping problematic items which led to admirable factor loadings, good construct reliability and validity, and discriminant validity. These evaluations confirmed that all indicators of the final measurement model adequately measure what they are intended to measure (Bagozzi & Yi 2012). Following this, the structural model was specified using a two-stage approach. The model was run to obtain the strength and significance of the hypothesised relationships. The two-stage approach also yielded latent variable scores that were used to specify the structural model (Figure 4.7). The model assessment revealed significant R^2 values at 95% confidence interval. Twelve out of the thirteen hypotheses were supported (Table 4.22). Though HSIs had a positive relationship with co-workers' safety behaviour, this link was not significant, and hence not supported.

The study found that through the school of effective rules, an increase in management commitment to safety positively influences the current safety rules and procedures. Once the safety rules and procedures are instituted, there would be an increase in management communication of safety (e.g., operates open-door policy, encourages worker feedback, communicates lessons from incidents, safety awareness programs, toolbox meetings, use of persuasion skills, face-to-face meetings), since workers must be aware of the behaviour that is supported and rewarded in the organisation. Then, through the lens of role theory, high management safety expectations positively affect the supervisory environment since supervisors' roles are moulded by the needs of management. Considering that supervisors make choices about how and which interventions to implement (Zohar 2008), an increase in the supervisory environment favourably influences the implementation of HSIs.

On the other hand, through social information processing and social learning, supervisors' frequent interactions with workers convey important cues to workers about the priority of safety. Hence, a good supervisory environment positively impacts the workgroup safety climate. The study found that through social exchanges the provision of HSIs positively affects workgroup safety climate. Based on role and organisational support views, HSIs were also found to strengthen the relationship between supervisory environment and workgroup safety climate. In addition, a partial mediation was revealed, as the supervisory environment influences the workgroup safety climate through HSIs. From social interactions and exchanges, workgroup safety climate had a positive relationship with co-workers' safety behaviour.

The results indicated that HSIs do not directly influence co-workers' safety behaviour; instead, an increase in HSIs improves the relationship between workgroup safety climate and co-workers' safety behaviour. Based on expectancy-valence and behavioural biases, co-worker safety behaviour was found to mediate the association between workgroup safety climate and co-workers' safety outcomes. This also suggests that positive co-workers' safety behaviour minimises co-workers' safety outcomes such as accidents/injuries and near misses. Finally, using relative values, the study showed the most significant paths for reducing the number of accidents and near-misses:

management commitment → current safety rules and procedures → management communication → supervisory environment → human safety interventions → workgroup safety climate → co-workers' safety behaviour → accidents/injuries and near misses (Figure 4.7).

6.2.5 Examine how co-workers safety outcomes predict workgroup safety climate perceptions

The fifth objective was addressed in Chapter Four using the PLS-SEM. This objective sought to answer the question, "do safety outcomes provide important cues to workers?". Specifically, when accidents/injuries and near misses occur, do they affect the perceptions workers form about the priority of safety in their organisation? This question is important because the outcomes of climate perceptions can, in turn, serve as predictors of climate, for example when accidents frequently occur at the workplace (which is a physical and social feature proximal to workers), it weakens their view about the value of safety in their organisation (Schneider et al. 2017). To address this question, the latent variable scores generated from the two-stage approach were used to specify the structural model (Figure 4.10). The model evaluation revealed that the assumed relationship was supported. The R^2 was also statistically significant at a 95% confidence interval.

The study found that safety outcomes such as accidents/injuries and near misses predict workgroup safety climate. Hence, an increase in those safety outcomes decreases the workgroup safety climate perceptions because, from symbolic interaction theory, the frequent occurrence of accidents informs and affects workers' interpretations of the prevailing conditions of how the organisation values safety, thereby weakening the perceptions workers form about the priority of safety (Bergman et al. 2014). Thus, co-workers' safety outcomes negatively affect the workgroup safety climate.

To summarise, management and supervisors can improve safety climate in workgroups by focusing on reducing accidents or near misses. Accident investigations can be performed to probe into how an accident or incident occurred in order not to repeat poor safety outcomes. Management can implement human safety interventions such as involving workers in job hazard analysis and providing safety inductions to new workers to improve their safety awareness and knowledge about reasons to work safely. This would lead to a continuous reduction of poor safety outcomes, since when accidents are low, workgroup safety climate increases, then when workgroup safety climate rises, accidents would, in turn, reduce, causing sustainable safety.

6.3 Theoretical Contribution

6.3.1 Extension of safety climate theory by adding antecedents

First, this thesis contributes to the expansion of safety climate theory in construction. The theory proposes that, at a given time, workers form perceptions about the value and priority of safety within their organisation. These perceptions are important because they predict safety performance. A considerable amount of research has made a significant contribution to this safety climate and performance association. However, very few studies in construction have investigated how climate perceptions are formed. This area of study is relevant because the ability to influence these perceptions would further affect safety outcomes. To the authors' knowledge, three studies were found in this respect, proposing communication network density, psychological contract, and social identity as predictors of safety climate in construction. In contributing to this niche area of study, this thesis proposed human safety interventions (HSIs), supervisory environment, and co-workers' safety outcomes as predictors of workgroup safety climate.

Human safety interventions as an antecedent of safety climate

Thus, a contribution of this thesis rests in the fact that it responded to the numerous unanswered calls to identify appropriate interventions likely to improve safety climate. Such interventions are needed because they strengthen workers' perceptions about the priority of safety in the organisation. From social exchange, the workers would reciprocate with good safety perceptions when they are provided with valued services and benefits, such as HSIs. Moreover, through social exchanges and symbolic interactions among workers and their immediate social and physical environment, HSIs offer multiple platforms (e.g., safety campaigns, awareness programs, bulletin boards etc...) for social interactions, which influence specific and generalised others at the workplace. HSIs also target the reduction of interpersonal risks during times of uncertainty and change. This is because, through learning behaviour, workers become knowledgeable and mindful about safety, hence reducing the anxiety associated with confronting ambiguity, changes and uncertainty when conducting their daily activities. Likewise, from the prospect view, HSIs such as safety incentives contribute to risk minimisation/avoidance since they counteract the tendency to underweight the long-term benefits of safe behaviour. These HSIs therefore operationalise the mediums for emergence and climate development.

Supervisory environment as an antecedent of safety climate

An additional contribution of this thesis is that it proposes that the supervisory environment would add to the formation of the safety climate perceptions developed within the workgroup. This works because through social information processing and social learning, how supervisors lead, and the environment they create for safety to thrive within shapes the views workers have about how the organisation supports and rewards safety. Hence, the supervisory environment contributes to the emergence of shared perceptions within the workgroup.

Safety outcomes as an antecedent to safety climate

Another significant contribution of this study is that while most of the studies have been too focused on examining how safety climate perceptions influence safety outcomes, no study has yet investigated the reverse in construction. That is, when accidents/injuries and near misses occur, do they affect the perceptions workers form about the priority of safety in their organisation? According to the symbolic interaction theory, workers in a group interpret events to determine the importance of a climate (Luria 2019). These accidents happen to co-workers at the workplace, occurring within social and physical proximities to the workgroup. Hence, the frequent occurrence of accidents informs and influences workers' interpretations about the prevailing ways in which the organisation values safety. This means that when these undesirable safety outcomes occur, they contribute to the formation of perceptions about how the organisation supports safety.

6.3.2 Co-workers as important safety agents

Importantly, another key contribution of this study is in the introduction of co-workers as important agents of change concerning safety matters. Co-workers are not just a crucial component of the social setting at the workplace, they actually define it (Schneider 1987). Despite the relevance of co-worker influence, most studies of safety climate are inclined to forget the function of co-workers and direct much effort to the study of workers' perceptions of supervisory leadership to denote the group safety climate. Thus, a few studies have explored how workers perceive their co-workers' commitment to safety, suggesting that the co-worker causal influence is not well understood in construction. On the other hand, most of the few studies that make the effort tend to treat co-worker safety and supervisory safety as a single factor of the group safety climate. As such, a more specific assessment may be required to evaluate these two unique agents (i.e. co-workers and supervisor) of the group safety climate system in isolation (cf. Andersen et al. 2018). Because the proximity of the worker-to-worker relationship is much closer than worker-to-supervisor, co-workers have a superior contribution to make strengthening safety climate perceptions in the workgroup. This implies that these two agents are not on the same level playing field.

6.3.3 Facets of group and organisational safety climates

The study further contributes to the theoretical arguments surrounding the components of safety climate and the level-of-analysis conundrum. Several safety climate studies still suggest ideal climate factors; nevertheless, this has encouraged the prevalence of dimensional inconsistencies and debate surrounding the concept of safety climate (Boateng, Davis & Pillay 2020). Drawing insights from comprehensive systematic reviews, meta-analytic evidence and safety climate pioneers, the study developed a framework (Figure 2.1) to capture specific dimensions of safety climate and particular levels at which they operate. It is anticipated that the framework contributes to clarifying the misperceptions and debates lingering around the dimensionality and operationality of safety climate.

6.3.4 Development of HSI scale

Relevant to both the theory of safety climate and the HSI construct, this thesis further contributed to the development and validation of the HSI construct. Building on the work of Zaira & Hadikusumo (2017), the study theorised the concept of HSI as a predictor of safety climate, and developed and validated two lower-order factors emanating from

HSIs. The two factors, sociological safety interventions and psychological safety interventions, were conceptualised as reflective-reflective higher-order constructs. This conceptualisation is important because it suggests an interplay between the two factors, offering opportunities for cross-fertilisation by considering contextual and structural constraints associated with a unidimensional view when offering insights on safety events. The validated HSIs scale could be used for monitoring and diagnosis of potential weaknesses of safety practices. Considering the call for research into the next chapter of safety climate research (Zohar 2010, 2014), the validated HSIs scale could be examined with safety climate and other established constructs as mediators, moderators, and antecedents to form a route to cultivating desired behaviour.

6.4 Methodological Contribution

Appropriate aggregation method for multilevel analysis

This research contributes to the few empirical studies on construction safety climate that have adopted the referent-shift consensus approach. This approach encourages employees to report on perceptions agreed upon in the organisation as well as its subunits. The approach shifts the referent from the self to the collective prior to consensus evaluation (Chan 1998; Glisson & James 2002; van Mierlo, Vermunt & Rutte 2009). Unfortunately, most studies assessing safety climate have mostly used self-report questionnaires (Newaz et al. 2018). The use of self-report data or a direct-consensus approach could result in common method bias and construct validity issues. Considering these flaws, studies using self-report data have often faced methodological criticisms from journal editors and reviewers during the review process (Chan 2009). As noted earlier in the literature chapter, self-reports are often necessary for self-perceptual assessments. On the other hand, for the concept of safety climate, which is theorised as being “shared” or “consensual”, among others, the referent-shift is a more appropriate aggregation method than self-reporting. These discussions suggest that the use of self-reports would undoubtedly stunt the growth of safety climate theory due to biased results informing further studies and policy. Thus, this study employing the referent-shift method, particularly at a multilevel, is essential for advancing safety climate.

Theoretical considerations for specifying safety measurement models

This study contributes to the methodological specification of safety measurement models. For example, based on Borman & Motowidlo (1993) distinction between task and contextual performance, safety compliance and safety participation emerged. These constructs were conceptualised by Neal & Griffin (2006) to define safety behaviour, suggesting that safety compliance and participation form safety behaviour. This means that safety behaviour is a reflective-formative construct (Figure 2.2). This is a type of construct where the relationship between the lower-order constructs (i.e. safety compliance and safety participation) and the higher-order construct is formative, and almost all of the variance of the higher-order construct variance is accounted for by the lower-order constructs (R^2 close to 1.0, see R^2s of 1.000 in Figure 4.5 for co-workers' safety behaviour and workgroup safety climate) (Matthews, Hair & Matthews 2018). These complex types of constructs and complicated relationships with other factors are best estimated using the partial least squares-structural equation modelling (Hair, Sarstedt & Ringle 2019; Lowry & Gaskin 2014). The covariance-based SEM is thus inappropriate for analysing complex constructs and models. However, observations and reviews (e.g. Boateng, Davis & Pillay 2019; Xiong, Skitmore & Xia 2015) show that most of the safety studies employed the CB-SEM. The use of factor-based/CB-SEM without the necessary theoretical reasoning can yield inaccurate results or erroneous tests. As observed by Hair Jr & Sarstedt, "The bias produced by factor-based SEM is on average 11 times higher than the bias produced by PLS-SEM when using each method on models inconsistent with what the methods assume" (Hair Jr & Sarstedt 2019, p. 621). The methodological contribution of this study rests in the careful consideration of the theoretical assumptions underpinning the composition of constructs to align with the conceptual premise of the analytical tools, hence providing reliable and valid results.

6.5 Empirical Contribution

How do HSIs affect workgroup safety climate and outcomes?

The study provides empirical evidence relevant for improving safety climate, safety behaviour and reducing accidents/injuries or near misses in construction projects. It suggests that the effective implementation of safety rules and policies depends on how management is committed to them, since power rests in them. The study emphasises that once the safety rules and procedures are developed, management can communicate them to workers to suggest the calibre of behaviour that is rewarded and encouraged at the workplace. This management communication of safety rules and procedures affects the supervisory environment because managers can instruct supervisors. The study showed that an increase in this supervisory environment increases the implementation of HSIs, since supervisors make decisions about how and which interventions to implement. On the other hand, the supervisory environment was also found to affect the workgroup safety climate. This works because when supervisors convey safety as a top priority, workers will also infer the same. The study proved the need to implement HSIs, as they influenced the workgroup safety climate. This is because through social interactions workers would reciprocate with higher levels of commitment when their organisation provided them with HSIs.

The results further revealed that, while the supervisory environment is acknowledged to influence workgroup safety climate, the implementation of HSIs had a beneficial effect as well. Likewise, the implementation of HSIs by supervisors strengthens the relationship between supervisory environment and workgroup safety climate. The study also revealed that, based on the principles of reciprocity, when workers perceive that their organisation values safety, they (co-workers) give back by performing the desired behaviour. The research emphasises that HSIs offer opportunities for workers to have multiple social interactions with workers and their immediate physical and social environment, hence improving the effect that workgroup safety climate has on co-worker safety behaviour.

A key finding of the study is that HSIs do not directly influence co-workers' safety behaviour, but influence co-workers' safety behaviour through workgroup safety climate. Thus, HSIs function as effect-modifying variables contributing to the climate-behaviour-accident model. The empirical results show that co-workers' safety behaviour is significantly linked with co-workers' safety behaviour, which further leads to a reduction in co-workers' safety outcomes. Also, the thesis indicated that when accidents/injuries and near misses occur, they inform workers about the fundamental safety climate in the organisation. As such, co-workers' safety outcomes is a predictor of workgroup safety climate. These empirical results suggest that HSIs, supervisory environment, and co-workers' safety outcomes affect the perceptions co-workers have about the colligated collection of safety experiences they have at work. This informs construction management on areas to focus on in improving safety performance of their workplaces.

What is the route to reducing poor safety outcomes?

The study also contributes to the evidence for the existence of a powerful route for minimising accidents/injuries and near misses. This path flows from management commitment → current safety rules and procedures → management communication →

supervisory environment → human safety interventions → workgroup safety climate → co-workers' safety behaviour → accidents/injuries and near misses. This path is important because it considers the formation of climate perceptions as a systematic process, given other contributory factors. Construction managers and supervisors could follow this route to examine their safety efforts in improving workers' safety perceptions to minimise accidents/injuries and near misses.

What are HSIs made of?

Finally, the thesis provides evidence of the dimensionality of the HSI construct. The empirical results indicate two lower-order constructs: psychological safety interventions and sociological safety interventions. The validated HSIs scale could be used for observing and detecting potential safety practice issues. The HSIs scale could be explored with safety climate and other established constructs as mediators, moderators, and antecedents to better our understanding of safety climate theory and related concepts.

6.6 Practical Implications

For the practitioner, these findings have some practical implications in the quest to have good safety performance. The study advocates that management can show their commitment to safety by establishing practical and effective rules and procedures. These realistic regulations can be created by socialising, encouraging, and consulting with workers on reaching a consensus about which rule works on the ground, and which does not. To communicate these rules and procedures throughout the organisation, management can engage supervisors to implement these policies, promoting safety awareness and knowledge among workers using proven methods such as *See the Difference* program. Management can also encourage feedback from workers and operate an open-door policy on safety issues, as this would make workers comfortable to discuss safety concerns that require improvement. Toolbox meetings can be used as a platform to share safety information. Management can adopt a more personal approach by using face-to-face meetings rather than hiding behind the veil of supervisors during the implementation of safety procedures. To workers, this approach improves their affective component of safety attitude which is important for both compliance and participation behaviours. Management can also immerse workers in a simulated environment such as virtual and augmented realities to strengthen this affective safety attitude. In times when safety rules and procedures seem abstract to workers, managers can deploy their persuasion skills to make workers realise their applicability and feasibility.

Construction managers should also emphasise safety as a top priority as a means to make supervisors concerned about safety matters. For example, management can achieve this reciprocity from supervisors by consistently providing career development opportunities for them, such as enrolling them in advance safety courses. Following this, when safety supervisors believe safety is paramount, it facilitates the implementation of HSIs and in turn, improves the perceptions workers have about the value of safety. These developments can be achieved when supervisors exhibit good behaviours such as listening, providing feedback, setting good safety examples, engaging in regular safety talks, and advocating working with safety procedures to meet deadlines. Also, management can offer HSIs such as adequate safety training, safety incentives, and behavioural based safety programs to workers, which would result in a mutual obligation for workers to respond with desired behaviours.

Sociological safety interventions such as safety training, toolbox meetings, safety inductions for new workers, and safety campaigns could be used as a platform for workers to have multiple social interactions to have homogenous perceptions on safety events and then exhibiting good safety behaviours as a response to the meanings of these perceptions. Similarly, psychological safety interventions such as easy access to information, adequate safety supervision, safety awareness programs, safety bulletin boards, and behavioural based safety can be used to reduce interpersonal risks in times of uncertainty and change since such interventions make workers knowledgeable and mindful, resulting in admirable safety behaviours. These good behaviours are expected to reduce the accidents and near misses on construction sites. Finally, the recommendations provided can be used by construction and safety professionals to focus their efforts on reducing poor safety outcomes, as it would further lead to cultivating good safety perceptions in workers.

6.7 Limitations

This study is not without limitations. First, a cross-sectional design was employed, hence it was not possible to understand how changes in workers' safety perceptions and the associated safety constructs in a dynamic environment like construction operate. The valid sample was also male-dominated, hence the results could be skewed in this respect. While the study made efforts to use questionnaires that capture most, if not all, safety climate dimensions, other factors contributing to safety climate theory may not have been considered. Further studies could incorporate additional variables in this direction to explain any variance. Also, not all relationships in the measurement models were accounted-for. Suggesting that an introduction of new associations between the constructs could affect the results. The study was also quantitatively inclined; however, complementing the quantitative study with qualitative data could have provided a deeper understanding of the causal influences operating among the various specified constructs.

6.8 Future Research

Systems view of safety climate

This research forms a stepping stone for future research needs within the safety climate-HSIs arena. Further studies could research the emerging field of a systems view towards safety climate theory. According to Hofmann, Burke & Zohar (2017), it remains a significant gap in viewing the general safety space from a systems perspective. This is because "research on safety climate [has] evolved rather naturally to include a more "organisation", or systems view of safety" (Hofmann, Burke & Zohar 2017, p. 383). Thus, although systems theory was not explicitly specified in this study, as, moreover, a cross-sectional approach was used, the theoretical model developed in this study transitioned from being perceived as an organisational-level construct to being integrated into a full multilevel model (Figure 4.7), implying more of a systems-focused model (cf. Hofmann, Burke & Zohar 2017; Zohar & Luria 2005). Hence further studies could integrate time delays, feedback loops, stocks and flows with the theoretical model presented in this study. This is important because such models depict a more practical and theoretical development of the safety climate concept within a dynamic work system over time (Casey et al. 2017). This dynamic orientation of safety climate formation and development has been an uncharted area of empirical study. The goal of this study would be to develop a system dynamic model to simulate the changes in workers safety perceptions over a project life span. Various safety agents could be integrated into the model to examine their roles and influences on the number of accidents/injuries within the allocated period.

Longitudinal approach to climate assessments among workgroups

Recently, social network theory has been infused with safety climate research in construction. This approach has provided evidence of the communication density and centrality as likely antecedents for group safety climate. However, further studies could embed this approach with the theoretical model developed in this research while considering longitudinal techniques. Assessments could be made at the beginning when forming the team/workgroup for the initial phase of the construction project, then during the actual execution and at the end of the project, when the team tends to disperse. This would provide interesting results as to the construction phase in which safety climate perceptions are the strongest. Other questions, such as, "when workgroup climate is at its strongest, does this necessarily mean co-workers' safety behaviour would be at its highest?" could also be addressed in future studies. While an increase in climate perceptions is established to influence behaviour, at what degree of climate strength could co-workers' safety behaviour tend to fall due to concepts such as "familiarity breeds contempt"? The goal of this study would be to determine the strength of safety perceptions during construction project phases using social network theory.

Role of informal groups in climate development

Also, construction safety climate studies have too often considered formal groups, of which this study is also guilty. However, the dynamic environment of construction, where social interactions abound, suggest that friendship networks would develop. That is, apart from the individual, workgroup, supervisors and managers, friends and cliques could be introduced as agents of change in the workgroup or workplace, because being in a group does not necessarily mean workers would communicate safety with others or even share the same safety perceptions. For instance, workers may communicate safety issues during lunchtime with their friends, who may not be in their formally assigned group in the organisation. From frequent interactions, these informal groups could influence how a formal group perceives the value of safety. The informal groups may also have a much stronger climate strength or homogeneity in safety perceptions than the formal workgroup. The aim of this study would be to examine the role of informal groups on safety climate development among construction crews.

Advancement of HSI scale

The HSIs scale developed in this study is conceptualised and validated as a reflective-reflective construct. Thus, it presents the opportunity to include other possible lower-order constructs to improve the HSI tool. It is expected that the refinement and continuous development of the HSIs scale would yield more robust and valid assessments of safety events at the workplace. The purpose of this study would be to improve the HSI scale in construction projects, or compare and validate the HSI instrument in developed and developing countries.

Comparative analysis of workers safety perceptions in diverse work forms

Different employment forms are apt to influence safety performance on construction sites. These employment forms could be short-term, casual, part-time, permanent, or full-time job arrangements. Construction workers perceptions in stable work forms or indefinite contract durations are likely to have a greater positive impact on safety performance than work engagements that are precarious or temporary. This could be attributed to the loose interpersonal and community relations associated with part-time workers (Anyfantis & Boustras 2020). This implies that, construction crews with stable work terms are more likely to form a consensual and homogeneous view about safety, unlike their counterparts with a temporary engagement. Moreover, temporary work types are linked to psychosocial risk factors health issues, restricted access to OHS professionals, job insecurity, fragmented legal responsibilities, and non-standard representation in OHS boards/agencies (Alamgir et al. 2008; Anyfantis & Boustras 2020; Burchell, Ladipo & Wilkinson 2001; Gimeno et al. 2004; Kieselbach et al. 2009; Witte

1999). For instance, in terms of job security, a worker could perceive that, "why waste efforts to work safely if I don't have a future with this construction company". Despite these reasons, other studies (e.g. Alali et al. 2016) do not support the assumption that permanent workers have lesser injury rates than temporary employees. Further research could provide more evidence in this aspect by exploring the underlying mechanisms that could explain how diverse employment types influence safety performance on construction sites, and across various cultures.

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APPENDIX

PhD Questionnaire for Survey

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

PhD Questionnaire

MAIN STUDY

Examining Structural Relationships between Organisational Safety Behaviour and Accident Causation: Patterns and Their Impact on Construction Project Performance

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Study Questionnaire

Important instructions

1. Please answer the questions by ticking {such as "✔"} or checking {such as "☒"}

Section A: Background of respondent

Q1. Kindly indicate your work trade.

1) Labourer ☐
2) Electrical & Mechanical worker ☐
3) Roofer ☐
4) Metal worker ☐
5) Welder / Boilermaker ☐
6) Traffic controller / Security ☐
7) Carpenter / form worker ☐
8) Bricklayer ☐
9) Linesman ☐
10) Insulation installer ☐
11) Concreter ☐
12) Painter ☐
13) Plumber ☐
14) Scaffolder ☐
15) Dogman ☐
16) Plant / equipment operator ☐
17) Carpet layer ☐
18) Glazier ☐
19) Millwright ☐

Other{s} {specify}: Click to specify others.

Q2. Your gender: 1) Male ☐ 2) Female ☐ 3) Not applicable ☐

Q3. Your years of working experience in the construction industry:

1) Less than 5 years ☐ 2) 5-10 years ☐ 3) 11-15 years ☐ 4) 16-20 years ☐ 5) More than 20 years ☐

Q4. Currently employed by: 1) Head Contractor ☐ 2) Subcontractor ☐

Q5. Current employment type: 1) Full-time ☐ 2) Part-time ☐

Q6. Length of service with the current organisation:

1) Less than 5 years ☐ 2) 5-10 years ☐ 3) 11-15 years ☐ 4) 16-20 years ☐ 5) More than 20 years ☐

<u>Section B: Measuring safety climate</u>

"**Safety climate** is the individual perceptions of the policies, procedures, and practices relating to safety in a workplace".

Information on safety climate is used to improve how an organisation rewards and supports safety

Using the rating system: **1** = strongly disagree; **2** = disagree; **3** = neither disagree nor agree; **4** = agree; **5** = strongly agree; please indicate your level of agreement on the following statements.

No.	Measures of safety climate	Level of agreement
	Commitment	
1	Management considers safety to be equally as important as production	☐1; ☐2; ☐3; ☐4; ☐5
2	Management expresses concern if safety procedures are not adhered to	☐1; ☐2; ☐3; ☐4; ☐5
3	Management acts decisively when a safety concern is raised	☐1; ☐2; ☐3; ☐4; ☒5
4	Management only acts after incidents have occurred	☐1; ☐2; ☐3; ☐4; ☐5
5	Management praises my co-workers for working safely	☐1; ☐2; ☐3; ☐4; ☐5
6	Management disciplines my co-workers for working unsafely	☐1; ☐2; ☐3; ☐4; ☐5
	Communication	
1	Management clearly communicates safety issues to my co-workers	☐1; ☐2; ☐3; ☐4; ☐5
2	Management always inform my co-workers about safety	☐1; ☐2; ☐3; ☐4; ☐5
3	Management operates an open-door policy on safety issues	☐1; ☐2; ☐3; ☐4; ☐5
4	Management encourages feedback from my co-workers on safety issues	☐1; ☐2; ☐3; ☐4; ☐5
5	Management communicates lessons from incidents to improve safety performance	☐1; ☐2; ☐3; ☐4; ☐5
	Current safety rules and procedures	
1	Current safety rules and procedures are made available to protect my co-workers from accidents	☐1; ☐2; ☐3; ☐4; ☐5
2	Current safety rules and procedures are adequate sources of information on safety for my co-workers	☐1; ☐2; ☐3; ☐4; ☐5
3	Current safety rules and procedures are so complicated that my co-workers do not pay much attention to them	☐1; ☐2; ☐3; ☐4; ☐5
4	Current safety rules and procedures require my co-workers to report any malpractice by a fellow worker	☐1; ☐2; ☐3; ☐4; ☐5
5	Current safety rules and procedures enforce my co-workers to use personal protective equipment whenever necessary	☐1; ☐2; ☐3; ☐4; ☐5
	Supportive environment	
1	In my group, we adopt a no-blame approach to unsafe work practices	☐1; ☐2; ☐3; ☐4; ☐5
2	In my group, we often remind each other on how to work safely	☐1; ☐2; ☐3; ☐4; ☐5
3	In my group, we believe it is our business to maintain a safe workplace environment	☐1; ☐2; ☐3; ☐4; ☐5
4	In my group, we always offer help when needed to perform the job safely	☐1; ☐2; ☐3; ☐4; ☐5
5	In my group, we ensure that individuals are not working by themselves under risky or hazardous conditions	☐1; ☐2; ☐3; ☐4; ☐5
6	In my group, we maintain good working relationships	☐1; ☐2; ☐3; ☐4; ☐5
	Supervisory environment	
1	My supervisor sets a good example	☐1; ☐2; ☐3; ☐4; ☐5
2	My supervisor believes safety is paramount	☐1; ☐2; ☐3; ☐4; ☐5
3	My supervisor usually engages in regular safety talks	☐1; ☐2; ☐3; ☐4; ☐5
4	My supervisor welcomes reporting safety hazards/incidents	☐1; ☐2; ☐3; ☐4; ☐5
5	My supervisor is a good resource for solving safety problems	☐1; ☐2; ☐3; ☐4; ☐5
6	My supervisor advocates working around safety procedures to meet important deadlines	☐1; ☐2; ☐3; ☐4; ☐5
7	My supervisor values my co-workers' ideas about improving safety when significant changes to working practices are suggested	☐1; ☐2; ☐3; ☐4; ☐5

No.	Measures of safety climate	Level of agreement
	Workers' involvement	
1	Everyone aims to achieve high levels of safety performance	☐1; ☐2; ☐3; ☐4; ☐5
2	Everyone plays an active role in identifying site hazards	☐1; ☐2; ☐3; ☐4; ☐5
3	Everyone reports accidents, incidents, and potentially hazardous situations	☐1; ☐2; ☐3; ☐4; ☐5
4	Everyone participates in safety planning, according to our safety policy if being asked	☐1; ☐2; ☐3; ☐4; ☐5
5	Everyone avoids being involved in accident investigations	☐1; ☐2; ☐3; ☐4; ☐5
6	Everyone contributes to risk assessments if being asked	☐1; ☐2; ☐3; ☐4; ☐5
	Co-worker appreciation of risk	
1	I believe that it is only a matter of time before my co-workers are involved in an accident	☐1; ☐2; ☐3; ☐4; ☐5
2	I believe my co-workers can influence the level of safety performance	☐1; ☐2; ☐3; ☐4; ☐5
3	I am clear about what my co-workers responsibilities are for safety	☐1; ☐2; ☐3; ☐4; ☐5
4	I believe that safety is the number one priority of my co-workers while working	☐1; ☐2; ☐3; ☐4; ☐5
5	My co-workers believe some rules are essential to get the job done safely	☐1; ☐2; ☐3; ☐4; ☐5
6	My co-workers believe some rules and policies are not practical	☐1; ☐2; ☐3; ☐4; ☐5
7	My co-workers cannot do the job safely without following every safety procedure	☐1; ☐2; ☐3; ☐4; ☐5
	Appraisal of the physical work environment and work hazards	
1	In our work environment, safety is a primary consideration when determining site layout	☐1; ☐2; ☐3; ☐4; ☐5
2	In our work environment, poor site layout planning is an accepted feature of the industry	☐1; ☐2; ☐3; ☐4; ☐5
3	In our work environment, the chances of being involved in a site accident are quite high	☐1; ☐2; ☐3; ☐4; ☐5
4	In our work environment, operating site conditions may hinder one's ability to work safely	☐1; ☐2; ☐3; ☐4; ☐5
5	In our work environment, detecting hazards is not a major aim of the site planning	☐1; ☐2; ☐3; ☐4; ☐5
6	In our work environment, working with defective equipment is not allowed under any circumstances	☐1; ☐2; ☐3; ☐4; ☐5
7	In our work environment, potential risks and consequences are identified before the execution of work	☐1; ☐2; ☐3; ☐4; ☐5
	Work pressure	
1	My co-workers work under a great deal of pressure	☐1; ☐2; ☐3; ☐4; ☐5
2	My co-workers are not given enough time to get the job done safely	☐1; ☐2; ☐3; ☐4; ☐5
3	It is necessary for my co-workers to deviate from safety requirements for production's sake	☐1; ☐2; ☐3; ☐4; ☐5
4	My co-workers perceive operational targets in conflict with some safety measures	☐1; ☐2; ☐3; ☐4; ☐5
5	It is normal for my co-workers to take shortcuts at the expense of safety	☐1; ☐2; ☐3; ☐4; ☐5
6	My co-workers tolerate minor unsafe behaviours performed by other workers	☐1; ☐2; ☐3; ☐4; ☐5
7	It is not acceptable to delay periodic inspection of plant and equipment	☐1; ☐2; ☐3; ☐4; ☐5
	Competence	
1	My co-workers received adequate training to perform their job safely	☐1; ☐2; ☐3; ☐4; ☐5
2	My co-workers are aware, through training, of relevant safety procedures	☐1; ☐2; ☐3; ☐4; ☐5
3	My co-workers are skilled at avoiding the dangers of workplace hazards	☐1; ☐2; ☐3; ☐4; ☐5
4	My co-workers are capable of identifying potentially hazardous situations	☐1; ☐2; ☐3; ☐4; ☐5
5	My co-workers are proactive in removing workplace safety hazards	☐1; ☐2; ☐3; ☐4; ☐5
6	My co-workers are capable of using relevant protective equipment	☐1; ☐2; ☐3; ☐4; ☐5

Section C: Human safety intervention practices

"**Human safety interventions** denote methods to change human understanding and reasoning given safety practices that directly affect the employee".

Information on human safety interventions is used to mould safety practices and programs provided by the employer

Using the rating system: **1** = strongly disagree; **2** = disagree; **3** = neither disagree nor agree; **4** = agree; **5** = strongly agree; please indicate how well your co-workers are provided with the following safety intervention practices by your employer.

No.	Practices of human safety intervention	Level of agreement
1	My co-workers are provided with adequate safety training for their job	☐1; ☐2; ☐3; ☐4; ☐5
2	Toolbox meetings are frequently organised for my co-workers to attend	☐1; ☐2; ☐3; ☐4; ☐5
3	My new co-workers are given safety inductions before commencing work	☐1; ☐2; ☐3; ☐4; ☐5
4	My co-workers are encouraged to get involved in safety campaigns	☐1; ☐2; ☐3; ☐4; ☐5
5	My co-workers are always involved in job hazard analysis (JHA) for specific tasks	☐1; ☐2; ☐3; ☐4; ☐5
6	My co-workers have easy access to safety information	☐1; ☐2; ☐3; ☐4; ☐5
7	My co-workers are given adequate safety supervision on site	☐1; ☐2; ☐3; ☐4; ☐5
8	My co-workers are provided with safety awareness programs	☐1; ☐2; ☐3; ☐4; ☐5
9	My co-workers are provided with workplace programs designed to influence their actions toward maintaining safe workplace	☐1; ☐2; ☐3; ☐4; ☐5
10	My co-workers are offered safety incentives (e.g. safety awards) for working safely	☐1; ☐2; ☐3; ☐4; ☐5
11	My co-workers have easy access to safety bulletin boards	☐1; ☐2; ☐3; ☐4; ☐5
12	My co-workers have the requisite safety certification for undertaking high-risk activities	☐1; ☐2; ☐3; ☐4; ☐5

Section D: Measuring safety performance

Q1. Safety compliance and safety participation

"**Safety Compliance** refers to the fundamental activities that individuals need to carry out to maintain workplace safety such as adhering to standard work procedures and wearing personal protective equipment".

"**Safety Participation** denotes behaviours that do not directly contribute to an individual's safety but that do assist in fostering an environment that supports safety such as attending toolbox meetings and helping co-workers with safety-related issues".

Using the rating system: **1** = strongly disagree; **2** = disagree; **3** = neither disagree nor agree; **4** = agree; **5** = strongly agree; please rate your level of agreement on the following statements.

No.	Safety compliance and safety participation	Level of agreement
	Safety compliance	
1	My co-workers use all the necessary safety equipment to do their job	☐1; ☐2; ☐3; ☐4; ☐5
2	My co-workers use the correct safety procedures for carrying out their job	☐1; ☐2; ☐3; ☐4; ☐5
3	My co-workers ensure the highest levels of safety when they carry out their job	☐1; ☐2; ☐3; ☐4; ☐5
	Safety participation	
1	My co-workers promote safety programs within the organisation	☐1; ☐2; ☐3; ☐4; ☐5
2	My co-workers put in extra effort to improve the safety of the workplace	☐1; ☐2; ☐3; ☐4; ☐5
3	My co-workers voluntarily carry out tasks or activities that help to improve workplace safety	☐1; ☐2; ☐3; ☐4; ☐5

Q2. Number of accidents/injuries and near misses

A **near miss** is an event in which no damage or injury occurs, but under slightly different circumstances, could have led to harm.

Using the rating system: **1** = never; **2** = one time; **3** = two to four times; **4** = five to seven times; **5** = over eight times; please rate according to the number of accidents/injuries and near misses in the past 12 months.

No.	Number of accidents/injuries and near misses	Number of times
1	How many times have your co-workers been exposed to a near miss incident of any kind at work?	☐1; ☐2; ☐3; ☐4; ☐5
2	How many times have your co-workers suffered from an accident/injury of any kind at work, but did NOT require absence from work?	☐1; ☐2; ☐3; ☐4; ☐5
3	How many times have your co-workers suffered from an accident/injury that required absence from work?	☐1; ☐2; ☐3; ☐4; ☐5

Q3. Safe work behaviour

Please circle on a scale of 0-100%, what percentage of time do you believe that your co-workers follow all safety procedures for jobs?

0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100

Thank you for your time

For any enquiries, please contact Emmanuel Bannor Boateng

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Participant Information Statement

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Participant Information Statement for the Research Project: Examining Structural Relationships between Organisational Safety Behaviour and Accident Causation: Patterns and Their Impact on Construction Project Performance

You are invited to participate in the research project identified above which is being conducted by Emmanuel Bannor Boateng (PhD Student researcher) under the supervision of Dr Manikam Pillay (Chief investigator), Prof Peter Davis (Co-investigator), and A/Prof Thayaparan Gajendran (Co-investigator), The University of Newcastle.

Why is the research being done?

The purpose of the research is to develop a model that predicts safety performance through the application of artificial neural network. Currently, fatality statistics as indicated by Safe Work Australia report that 35 construction workers are seriously injured each day on construction sites. To address such issues, the Australian Work Health and Safety Strategy 2012-2022 was formulated to drive key national activities to achieve improvement in occupational health and safety. The implementation of the Strategy successfully brought massive declines in the number and rates of fatalities in its initial resultant year i.e., in 2013, however, the subsequent years have experienced continuous higher numbers and rates of injuries in the construction industry. Accidents can occur through individuals' participation in their work. Health and Safety Executives report that 80% of accidents may be attributed, at least in part, to the actions or omissions of people. It is vital for construction organisations to explore effective methods to monitor safety performance. This involves the use of appropriate tools such as the artificial neural network to make predictions that are more accurate. This could enable construction managers and supervisors to be aware of the level of safety performance on a project and to take any necessary corrective actions to minimise the probability of accidents. Understanding and predicting safety decisions could help encourage compliance with current processes and design better interventions leading to improved safety performance on large construction projects.

Who can participate in the research?

You are invited to participate if:

- You are employed by a construction company or your employer works in the construction industry;
- You are more than 18 years old;
- You have a trade and are actively employed in your trade such as a roofer, carpenter, painter, or dogman etc.

- You have at least one-year experience in the construction industry.

What would you be asked to do?

If you agree to participate, you will be asked to complete an anonymous survey in groups using the audience response system (ARS). ARSs employ electronic handheld response keypads ("clickers") that allow you to respond with individual clickers and anonymously to multiple-choice questions. The questions are displayed onscreen in a PowerPoint format and the audience responds by entering their answers using the clickers. No identifying data is collected. You can respond by clicking, knowing that your response is anonymous and cannot be revealed publicly. Hence, your anonymous responses are sent directly to the student researcher's laptop. Only the student researcher has access to the password-protected laptop. You can respond to ARS questions without being judged by other participants, or the presenter. Your manager has provided consent for your participation but will not have access to the collected data. The survey will be administered using the ARS at a predetermined time at your workplace. The survey may take place during your toolbox meeting or available time suitable for your participation as set by your organisation. Prior to the survey, you will have a week to read and think about the information statement and consent form, and ask any questions by contacting the student researcher. The survey questions will be based on safety management in relation to Safety Climate, Human Safety Interventions, and Safety Performance. Safety climate consists of 62 questions, human safety interventions consist of 13, and safety performance consists of 10 questions. Example of safety climate question is "Everyone has the responsibility to reflect on safety practice" which is rated on a five-point Likert scale from strongly disagree (1) to strongly agree (5)". Six (6) questions on the respondent background would be asked on the kind of work trade, gender, length of service with the organisation, and years of working experience in the construction industry. You will also be asked to sign a consent form prior to participation in the study. ARS uses a combination of software and hardware to present questions and record responses. Participants will be given clickers to select a response on a scale of 1-5 for most questions and 0-100% for a question.

How much time will it take?

The survey would take approximately 40 minutes to complete.

What choice do you have?

Participation in this research is entirely voluntary. Only those who give their informed consent will be included in the project. Whether or not you decide to participate, your decision will not disadvantage you. Upon agreement to participate, you can withdraw from the study at any time and do not have to give any reason for this withdrawal.

***What are the risks and benefits of participating*?**

There may be some professional and personal risk during the research process. These risks in the context of this study refer to the potentially sensitive nature of the information asked as some of the questions are related to workplace practices and relationships. These risks will be managed by keeping all information you provide confidentially, and you will not be named or identified in any reports arising from the project. The expected benefits of participating in this study will contribute to the understanding of safety compliance and safety participation.

How will your privacy be protected?

Your participation is voluntary and your confidentiality will be maintained at all times. Your name or any other identifying data will not be collected. All your responses are strictly confidential. Your manager has provided consent for your participation but will not have access to the collected data. The de-identified data collected from your site are shuffled together with other sites for analysis; hence, no single site and their responses are isolated. Data collected through the ARS is instantly de-identified. Clickers will be handed out randomly to consenting participants. Thus participants and organisations do not have the option to withdraw from the study once the ARS is completed because their responses cannot be identified.

All of the data collected will be stored electronically and password protected. Electronic data will be backed up by the student researcher (EBB) ownCloud account. Hard copy records (including signed consent forms) will be stored in a locked cabinet accessible only to student researcher and named investigators. Following completion of the study, all data will be stored for a minimum of 5 years, in accordance with the University of Newcastle Research Data and Materials Management Policy.

How will the information collected be used?
The collected data will contribute to the understanding of safety compliance and safety participation in order to provide a safer workplace. The results will be published in peer-reviewed journals, as part of Emmanuel's PhD thesis and presented at professional conferences in a de-identified form. De-identifiable data may be also be shared with other parties to encourage scientific scrutiny and to contribute to further research and public knowledge, or as required by law. The researcher will provide a summary of results to all consenting organisations as well as individuals if they indicate their interest on consent forms.

***What do you need to do to participate*?**
Please read the Information Statement and be sure you understand its contents before you consent to participate. If you wish to participate in this study, please complete the accompanying consent form along with the survey information statement.

Further information
If you would like further information or if you have any questions please contact:

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Phone: +61424209421

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Chief Investigator
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Phone: +61249217438

Thank you for considering this invitation.

Kind regards

Dr Manikam Pillay	Mr Emmanuel Bannor Boateng
Chief Investigator	Student Researcher

Complaints about this research
This project has been approved by the University's Human Research Ethics Committee, Approval No. H-2018-0462. Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Services, NIER Precinct, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone