Title:

A study on the health and safety of Chinese migrant workers in the New Zealand construction industry

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in School of Built Environment at Massey University, Albany, New Zealand

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Abstract

The construction sector is a labour-intensive industry with high risks, where workers frequently face a variety of safety hazards on site. The continued advancement of globalisation has led to a rise in overseas migration, making migrant workers an increasingly important part of the construction industry's labour force. New Zealand (NZ) has experienced a rise in demand for skilled construction workers, a trend that has become even more pronounced in the aftermath of the COVID-19 pandemic. Migrant construction workers are characterised by their high mobility, easy recruitment, and lower wages, which meet the dual needs of construction companies for human resources and cost control. However, migrant construction workers face challenges to safety management on construction sites due to factors such as language barriers, limited safety awareness, and unfamiliarity with safety policies. Chinese migrant construction workers (CMCWs) play a vital role in the global construction workforce. However, like other migrant workers, they face greater vulnerabilities on overseas construction sites compared to local workers. Given their significant contribution to the industry, the existing research on the health and safety of CMCWs should be expanded, with a deeper focus on addressing these challenges.

This thesis explores the influencing factors affecting the health and safety of CMCWs and investigates effective solutions for improvement. This study used qualitative and quantitative methods to achieve the research objectives, including a systematic literature review, partial least squares structure equational modelling (PLS-SEM), and the development of a web prototype platform.

The study outlines the definition of CMCWs and identifies various safety-influencing factors. Incentive strategies, particularly financial incentives, are seen as effective in improving CMCWs' safety compliance. However, key factors influencing their safety outcomes include their understanding of safety policies and personal variables such as safety awareness, education, and compliance. This research reports that the impact of language barriers and cultural differences on communication at New Zealand construction sites among CMCWs is not a major health and safety influence. This finding can be attributed to the preference of Chinese migrant workers to select construction sites with the same language environment, thereby mitigating the impact of language barriers and cultural differences on their safety communication. However, language barriers and personal factors contribute to the ineffectiveness of safety training when not tailored or targeted for subsets of the workforce. To address the needs of Chinese migrant construction workers, a novel safety web platform was developed to evaluate the effectiveness of this solution in improving CMCWs' health and safety standards.

This thesis offers theoretical guidance and practical data to support research in the realm of health and safety concerning migrant construction workers. Furthermore, the in-depth research on the health and safety of CMCWs also provides both practical and theoretical guidance for other researchers who are pursuing closely related research topics. The practical results and experimental data can contribute to New Zealand construction groups' comprehension of the requirements of and challenges facing migrant construction workers in safety-related domains. The NZ government and construction societies can develop effective safety management strategies to improve the health and safety of CMCWs.

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“爸爸妈妈我爱你们，这篇大论文是感谢你们这 4 年来对我的爱和支持的表达。我会永远爱你们并努力成为更优秀的人回报你们。我这些年过得很好，永远爱你们！！！”

Publications

Four journal articles have been published or are under review at the time of finalising this thesis. These are:

Published journal papers:

Guan, Z., Yiu, T.W., Samarasinghe, D.A.S. and Reddy, R., (2024). Health and safety risk of migrant construction workers–a systematic literature review. Engineering, Construction and Architectural Management, 31(3), pp.1081-1099.

Journal papers under review:

Guan, Z., Yiu, T.W., Samarasinghe, D.A.S., Ian Laird., and Reddy, R. Improving Health and Safety in Construction Workers through Incentive Strategies: A Systematic Literature Review. (**ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering)**

Guan, Z., Samarasinghe, D.A.S., Yiu, T.W., Ian Laird., and Reddy, R. Investigating Factors Affecting Health and Safety Outcomes of CMCWs: A PLS-SEM Study. **(Engineering, Construction and Architectural Management)**

Guan, Z., Samarasinghe, D.A.S., Yiu, T.W., Ian Laird., and Reddy, R. Building Safety Bridges: A Comprehensive Exploration of a Health and Safety Platform for Migrant Construction Workers. **(Safety Science)**

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List of Abbreviations

AVE	Average Variance Extracted
BIM	Building Information Modelling
BLS	Bureau of Labour Statistics
CIOB	Chartered Institute of Building
CR	Composite Reliability
CFA	Confirmatory Factor Analysis
CB-SEM	Covariance-based SEM
CA	Cronbach's Alpha
CMCWs	Chinese Migrant Construction Workers
EU	European Union
EFA	Exploratory Factor Analysis
HSW Act	Health and Safety at Work Act
HSE	Health and Safety Executive
HTMT	Heterotrait-monotrait ratio of correlations
IPMA	Importance-performance matrix analysis
I/P	Incentive/Punishment
ILO	International Labor Organization
IOM	International Organization for Migration
NZ	New Zealand

NZCI	New Zealand construction industry
NZCBIA	New Zealand Chinese Building Industry Association
ORD	Ordinal data
PLS-SEM	Partial least squares structure equational modelling
PRC	People's Republic of China
PCBU	Person conducting a business or undertaking
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PPE	Personal Protective Equipment
SEM	Structural Equational Modelling
UAE	United Arab Emirates
UK	United Kingdom
US	United States
WSH	Workplace Safety and Health
VIF	Variance inflation factor
VR	Virtual Reality

CHAPTER 1

Introduction

1.1. Background

The construction industry is considered a high-risk industry due to its high frequency of occupational injuries and fatalities (Martínez-Rojas et al., 2022, Kim et al., 2019). In 2019, the United States (US) recorded 1,102 fatal injuries in the construction industry, representing 20.7% of total workplace fatalities (United States Bureau of Labour Statistics, 2021). In addition, US construction workers experienced 3,950 cases of onsite nonfatal injuries or illnesses in 2020 (Nichole Helmick and Petosa, 2022). In the United Kingdom (UK), the construction industry experienced a higher number of fatal incidents than other industries like agriculture, manufacturing, and transport, and the fatality rate of construction workers was over three times higher than the average fatality rate between 2016 and 2017 (Zaptic, 2023). The number of fatal injuries in the construction industry was 30 in 2021 to 2022, accounting for approximately 40% of the total fatal injuries in work-related incidents (Health and Safety Executive (HSE), 2023). The construction industry in Australia ranks as the third most unsafe industry, with a fatality rate of around twice the average work-related fatality rate (PRO Choice Safety Gear, 2013). Although rate of fatalities decreased from 2007 to 2018, there were still 183 fatal incidents in 2019 (Safe work australia, 2021).

It was reported (Worksafe, 2023a) that the construction industry in New Zealand (NZ) experienced 27,006 injuries between 2018 and 2022 that resulted in the workers being off the job for more than a week. In addition, there were 2,776 cases of injury, illness and serious harm from 2018 to 2022 (Worksafe, 2023b). Hence, to lower incident rates it is timely to improve safety management on construction sites. An aim of this study is to propose an innovative safety management approach aimed

at improving the overall safety within the New Zealand construction industry (NZCI) and lowering the likelihood of safety incidents.

1.2. Migrant workers in the construction industry

The construction industry is labour-intensive and plays a vital role in a country's economic and social development (Ng and Tang, 2010). Despite the heightened risks, workers, particularly migrant construction workers, persist in joining the industry each year (Buckley et al., 2016). There were approximately 169 million international migrant workers in 2019 accounting for 4.9% of the labour force in the destination countries (Rakotonarivo, 2021). The number of international migrants worldwide in 2020 reached around 281 million, an increase of more than 100 million over the 2019 figure (International Organization for Migration (IOM), 2022). In the US, 24% of the construction labour force in 2019 were immigrants (Hammad et al., 2023). In the UK, the number of overseas migrants increased from 88,000 in 2003 to 240,000 in 2015 (Oswald et al., 2019), with migrants comprising 14% of construction workers in 2017 (Winterbotham et al., 2019), while in Australia, one-third of workers were migrants (Kozanoglu et al., 2023). The proportion of migrant workers is estimated to be 7% to 10% of the total construction workforce in NZ (Ministry of Business, 2021).

Migrant construction workers make positive contributions to the host countries' construction industry by providing skilled workers, innovation, and entrepreneurship (Kozanoglu et al., 2023, Canello, 2016, Crown et al., 2020). Migrant workers have become a vital source of the labour force in the construction industry of various countries (Shepherd et al., 2021). However, compared with native workers, migrant construction workers have a higher risk of injury due to factors such as language barriers, insufficient safety training, discrimination and so forth (Ibarra-Mejía et al., 2021, Fernández-Esquer et al., 2020). Therefore, the health and safety of migrant construction workers has become a popular direction in current academic research. While the number of studies on migrant workers has increased over the past decade, there remains limited research explicitly addressing the health and safety of migrant

construction workers. The scarcity of literature on migrant construction workers may be attributed to several factors. Firstly, migrant workers in the construction industry are characterised by growing numbers and high mobility, which challenges accurate and reliable data collection and analysis by countries or institutions related to migrant worker health and safety for (Dong and Platner, 2004). Secondly, construction companies are not welcoming of research and are hesitant to disclose incidents in order to maintain a good reputation (Machado Susseret et al., 2019). Lastly, migrant construction workers might also conceal injuries to preserve their employment (Menzel and Gutierrez, 2010).

1.3. Selection of sample group

With the development of globalization, CMCWs have gradually become one of the main labour resources in international labour force markets (Ai, 2022). PRC is fourth among the top 10 countries of origin for migrant workers (Pew Research Center, 2012). As of 2011, the global overseas Chinese population exceeded 40.3 million (Poston and Wong, 2016) and there were approximately 1 million Chinese migrant workers at the end of 2019 (Chen, 2022). Chinese migrant workers are distributed across nearly every country (Poston, 1990), with the primary destination countries for Chinese migrants being Australia, Canada, NZ, and the US (Poston and Wong, 2016). Chinese migrant workers are one of the main labour forces in the construction industry (Kilgallon and Xia, 2021).

There are three reasons for choosing CMCWs as the research subjects in this thesis. Firstly, despite the progressive integration of Chinese migrant workers as one of the major labour forces in the construction industry, there is a lack of data and research related to health and safety factors and prevalence of incidents occasioning injury and fatality for this group (Liu and Lu, 2015). Secondly, there is a strong in-group identification among Chinese groups (Yin, 2015). Chinese migrant workers exhibit a preference for interacting with individuals speaking the Chinese language owing to challenges posed by linguistic barriers. One of the researchers is a native of China and fluent in the language, which is beneficial for research teams to communicate with sample groups and collect data.

Thirdly, the research data mainly originates from the construction industry in Auckland, NZ. Chinese migrants have consistently been a significant labour source in NZ. For instance, there were more than 10,000 immigrants in NZ from the People's Republic of China (PRC) between 1987 and 2009 (Liu, 2010). In 2006, over half (77,157, 52.29%) of NZ's Chinese population originated from PRC (New Zealand Immigration Services, 1995). Chinese migrant workers remain one of the largest migrant groups in the Auckland construction industry, accounting for 16% of all overseas migrant workers from 2016 to 2018 (Sweet Analytics, 2023). Hence, in research exploring the health and safety of migrant construction workers, Chinese migrant workers were considered the focus of this study's sample group.

1.4. Research gaps, aims, questions, and objectives

This thesis will first address the research gap in the health and safety of Chinese migrant workers in the NZCI. Currently, there is a research gap in both academic studies and data statistics regarding the health and safety of CMCWs in NZ. On the one hand, there a paucity of literature on CMCWs in NZ within popular databases like Scopus. On the other hand, official NZ websites (such as WorkSafe and Site Safe) lack detailed data on "CMCWs". Most data statistics on official government websites only provide general data on "Chinese migrant workers across all industries" or "migrant construction workers of all nationalities".

This thesis will narrow the research gaps and conducts a comprehensive series of studies investigating the factors and solutions related to the health and safety of Chinese migrant workers in the NZCI. The final aim of this thesis is to draw general rules of health and safety investment for the health and safety of Chinese migrant workers in the construction industry in different countries. This thesis is divided into three stages corresponding to the research questions given below.

Q1 What is the definition of CMCWs in this study?

Q2 What are the general factors related to the health and safety of Chinese migrant workers in the construction industry?

Q3 Which solution(s) can motivate Chinese migrant workers in safety performance in the construction industry?

Q4 What is the significant factor and the inter-relationship between each factor?

Q5 What strategies can be employed to mitigate the impact of key influencing factors on the safety risks faced by CMCWs in NZ?

Each research question is linked to a corresponding research objective. The following four research objectives in this thesis are:

1. To conduct systematic literature reviews to explore the safety influencing factors (Chapter 2).
2. To conduct systematic literature reviews to explore an existing solution strategy to enhance safety performance (Chapter 3).
3. To conduct an in-depth analysis of the key factors affecting the health and safety of CMCWs and identify the inter-relationship between each factor. (Chapter 4)
4. To explore a novel safety strategy to improve the health and safety of CMCWs. (Chapters 5)

The first research question is the foundational question that supports the entire doctoral research. This research question pertains to academic fundamentals and, as such, does not align with any specific research objective. It should be addressed at the beginning of the study (in Chapter 2). Research objectives 1 and 2 are general inquiries, corresponding to Q2 and Q3. These two questions and objectives establish fundamental academic theories for subsequent research. Objective 3 aligns with Q4. This research objective aims to conduct an in-depth analysis to explore the health and safety of CMCWs. This research results will provide data and theoretical support for solution strategies. Objective 4 is linked to Q5, which proposes a novel strategy to improve the health and safety of Chinese migrant workers in the NZCI.

1.5. Summary of the overall research methodology

There are three main research methodologies: qualitative, quantitative, and mixed methods (Gray, 2022). The choice of a research methodology is predominantly contingent upon the respective research field and the types of research questions (Marczyk et al., 2005). Qualitative and quantitative research methodologies can be distinguished by the utilisation of numeric data within the research framework (Saunders et al., 2016). Quantitative research methodologies emphasize statistical analysis to derive research findings, incorporating systematic measurement and the utilisation of statistical data, whereas qualitative research methods provide in-depth analysis of the research subject through interviews and observations (Marczyk et al., 2005).

As mentioned above, this thesis adopts qualitative or quantitative research methodologies to achieve various research outcomes according to the research objectives and research questions at different stages. The research methodologies employed at each stage are delineated in Figure 1.1.

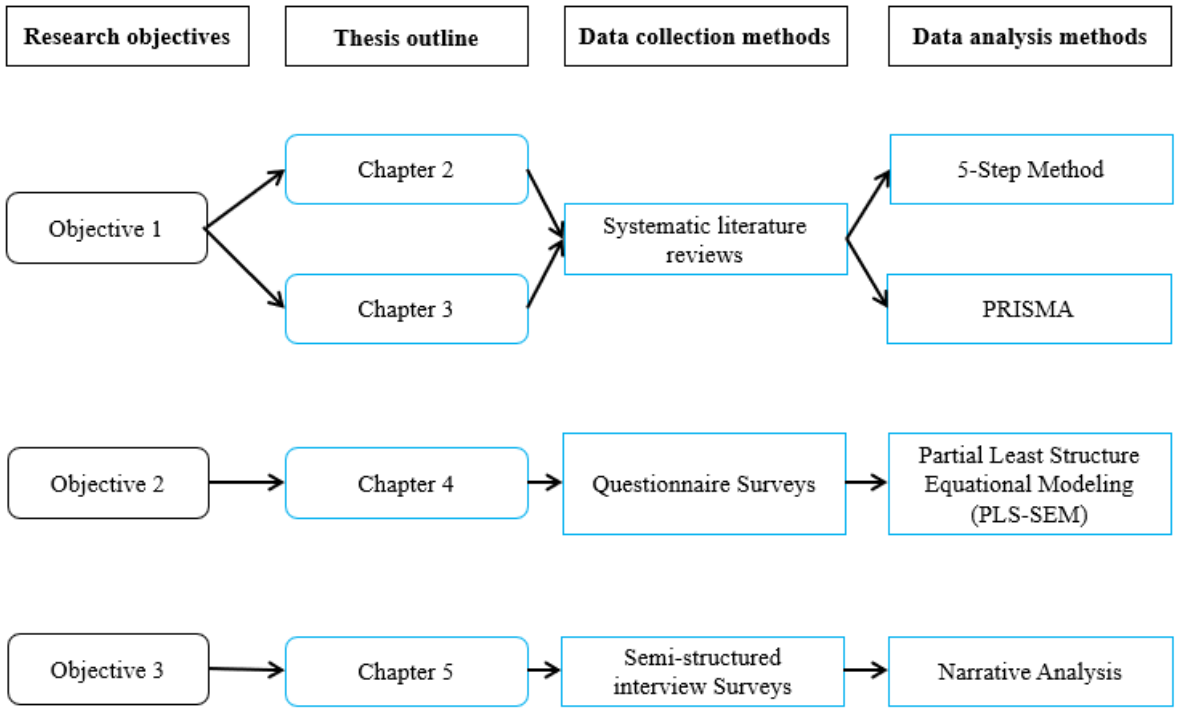

Figure 1.1. Research methods adopted in each chapter

Figure 1.1 demonstrates the research stages, research objectives, thesis outline, and research methods (including data collection and data analysis methods). The data collection methods encompassed systematic literature reviews (Chapters 2 and 3), questionnaire surveys (Chapter 4), and semi-structured interview surveys (Chapter 5). The data analysis methods included the 5-step method detailed in Chapter 2, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) in Chapter 3, the partial least squares structure equational modelling (PLS-SEM) in Chapter 4, and narrative analysis in Chapter 5.

In this thesis, two systematic literature review methods (5-step method and PRISMA) were used in this thesis to summarise the literature in the research field and achieve objective 1. A systematic literature review is not only a comprehensive and all-encompassing examination of the existing literature related to a research question, but can also be beneficial for strengthening the foundational knowledge of a specific topic while adhering to the principles of transparency and bias reduction (Williams et al., 2021). Moreover, systematic reviews and meta-analyses can offer the opportunity to critically assess and thoroughly aggregate the findings from multiple comparable trials, which can enhance the statistical power of the research (Sohrabi et al., 2021).

Objective 2 aims to identify the relationship between key influencing factors related to the health and safety of CMCWs. This objective was achieved by PLS-SEM, which can simplify not only intricate structural models but also explain multiple statistical relationships through visualization and model validation (Dash and Paul, 2021). In essence, PLS-SEM has the characteristic of both factor and multiple regression analyses (Dash and Paul, 2021). It is beneficial in clarifying the interrelationship

between latent constructs (or latent factors) by various measures (Hooper et al., 2008). The application of SEM in this thesis proves to be highly efficient in evaluating the reliability and validity of the measures related to five key influencing factors among CMCWs.

The data collection method for objective 3 was survey by semi-structured interview, and the narrative analysis method was used to emphasise the examination of the content and contextual dimensions of individuals' experiences. Narrative analysis is a qualitative research methodology employed to explore how individuals or groups interpret their experiences through the construction and communication of stories (Franzosi, 1998). This method is beneficial to the thesis in terms of systematic classification and hierarchical analysis of the respondents' feedback.

1.6. Outline of thesis

This thesis is organised following Massey University Graduate Research School's Doctoral Thesis with Publications guidelines. This section briefly introduces the structure of this thesis, and detailed descriptions are given in the following chapters. Chapter 1 serves as the general introductory chapter, while Chapter 6 summaries the whole research outcomes of this study. Chapters 2, 3, 4, and 5 have all been written as papers for peer review publication. The inherent relationships between the chapters are elucidated within chapter abstracts.

Chapter 1 provides a comprehensive overview of the research background, including research objectives and research groups. It also offers an overview of the research methodology, and ethical considerations. This chapter also sets out the structure of the study, with a summary of objectives, methods, activities, and brief results from the next chapters.

Chapter 2 Chapter 2 defines the research sample groups and examines the influencing factors affecting the health and safety of migrant construction workers from an international perspective. Drawing upon findings from a systematic literature review, this chapter establishes the definition of CMCWs and systematically categorizes the factors influencing the health and safety of this demographic.

Chapter 3 examines the effectiveness of safety incentives on the safety performance of migrant construction workers through a systematic literature review. This Chapter not only provides a comprehensive overview of the various existing safety incentives but also analyses the effectiveness of different safety incentives and the influencing factors that may affect the effectiveness of incentive strategies.

Chapter 4 explores the inter-relationship between the influencing factors identified in Chapter 2 and the safety outcomes of CMCWs. The study uses Partial Least Squares Structural Equation Modeling (PLS-SEM) to establish a theoretical data model and to conduct a significance analysis.

Chapter 5 A web prototype was developed, informed by collected data, to evaluate the effectiveness of the safety platform in improving the health and safety of CMCWs.

Chapter 6 This chapter outlines the practical implications, contributions to academia and the construction industry, and limitations of the study while also offering guidance for future research on the health and safety of migrant construction workers.

CHAPTER 2

A review of general influencing factors for Chinese migrant construction workers from international perspectives

This chapter is an extended version of the following journal article, which has been published in the Journal of Engineering, Construction and Architectural Management.

Guan, Z., Yiu, T.W., Samarasinghe, D.A.S. and Reddy, R., (2024). Health and safety risk of migrant construction workers–a systematic literature review. *Engineering, Construction and Architectural Management*, *31*(3), pp.1081-1099.

Abstract

The construction industry has long been perceived as a high-risk, labour-intensive domain. With the continuous development of globalization, migrant workers have increasingly become a vital labour resource within the construction industry, including NZ where there has always been a shortage of skilled construction workers. In NZ, Chinese migrant construction (CMCWs) workers constitute a significant portion of foreign labour in the construction sector, particularly in Auckland. Consequently, enhancing the health and safety of CMCWs can significantly contribute to raising the overall safety standards of construction sites in NZ. This chapter explores the safety influencing factors. A systematic literature review based on existing articles from international perspectives was conducted by the 5-step method to achieve research objectives in this Chapter. The findings reveal that CMCWs can be regarded as *"migrant workers who have Chinese Citizenship and have legal work in the construction industry outside of their country of origin".* In addition, the results of the systematic literature review reveal that the factors influencing the health and safety of migrant construction workers can be categorized into three levels: Personal Factors (micro-level), Cultural Factors (meso-level), and Organizational Factors (macro-level). The precise definition of CMCWs used for this study contributes to screening the sample group for subsequent studies. Furthermore, this study clarifies the influencing

factors for the health and safety of migrant construction workers from an international perspective, thus providing a critical foundation for subsequent in-depth analyses.

2.1. Introduction

In many countries, a significant challenge in the construction industry is the shortage of skilled labour. (Ackrill et al., 2017, Pan et al., 2020). For instance, according to the Chartered Institute of Building (CIOB), 157,000 new recruits were needed in the UK construction industry by 2021 to meet the demand (Price， and Wales, 2020). It was anticipated that the Australian construction industry would necessitate either a 30% increase in the existing workforce or an approximately 300,000 extra construction workers by 2025 (Master Builders, 2015). In NZ, 68% of construction companies were experiencing expansion limitations due to the skill shortage (Lobo and Wilkinson, 2008). This challenge stems from several factors like the ageing population and limited availability of labour in the construction market (Lecours et al., 2023). In order to address this challenge, many construction companies turn to the employment of migrant workers from overseas as a common strategy (Tan and Cebulla, 2023). The utilisation of international migrant workers could bridge the gap between the shortage in demand and the supply of skilled construction workers (Lai and Rasheed, 2021). However, studies have shown that the health and safety of migrant construction workers cannot be effectively guaranteed, (for instance Dong et al., 2009, Dutta, 2017, Hussain et al., 2020). In the US, the fatalities of Hispanic workers made up 29.1% of total fatalities in the construction industry in 2013 (Lyu et al., 2018). In some US states, such as Kentucky, the mortality among migrant construction workers is nearly twice as high as that of native workers (Cruz et al., 2018). In the UK, the fatalities of migrant construction workers accounted for 17% of all work-related fatalities (Hussain et al., 2020). This indicates that further research is necessary to explore the factors affecting the health and safety of migrant workers in the construction industry. This research is a preliminary study to explore the health and safety of migrant workers in the construction industry. The preliminary research is divided into two parts to determine the current situation of migrant workers in the construction industry. Using the

existing literature, the first part determines a unified definition of migrant workers, and the second part explores the related influencing factors affecting the health and safety of migrant workers.

2.1.1 The importance of a unified definition

According to the International Organization for Migration (IOM), the current definition of migrant workers in the construction industry is ambiguous (International Organization for Migration (IOM), 2019b). Long-term theoretical and practical research advancement in this field will not happen if academics and practitioners do not adopt a unified definition (Gong and Ribiere, 2021). For instance, a unified definition could facilitate the necessary protections and support for migrant workers in the construction industry through the safety policies and programmes of the government or organizations (Hannigan et al., 2016). If they had a unified definition, policymakers and safety managers could devise precise and effective solutions that address the unique demands or challenges faced by migrant workers (Anderson and Blinder, 2011). Furthermore, diverse definitions will have a detrimental influence on the statistical and categorization of migrant workers by governments and researchers due to the substantial number and high mobility of migrant workers (Dong and Platner, 2004). This could not only affect the accuracy and efficiency of data collection on migrant workers but also cause problems with interpretation (International Organization for Migration (IOM), 2019a). For example, different governments or researchers who are involved in collecting, collating, or researching the data will have different opinions on the definition of migrant workers, which will reduce the usability and validity of the research findings of the data screening (Parker, 2005). For instance, in NZ, while some government websites like Site Safe, Stas NZ, and WorkSafe NZ, had statistics on “migrant workers” and “construction workers”, there was less data support for “migrant construction workers” in the databases. Therefore, it is essential for this study to adopt a unified definition to ensure data collection in and for future research. This unified definition will also facilitate the effectiveness of research and bridge existing research gaps on the health and safety of migrant workers in the construction industry.

2.1.2 The importance of identifying the influencing factors

Multiple studies have shown that migrant workers in the construction industry are at a higher risk of injuries compared to native workers(Vignoli et al., 2021, Chávez and Altman, 2017, Grzywacz et al., 2012). Compared with the research on the health and safety of native construction workers, the literature about migrant construction workers is relatively limited (Rabito et al., 2011, Teran et al., 2015, Lara et al., 2021). There are several reasons causing this situation. Firstly, it is challenging for governments or organizations to gather influencing factors that impact the health and safety of migrant workers in the construction industry because of the highly mobile character of migrant workers (Dong and Platner, 2004). Secondly, construction companies may conceal the incidents on construction sites or be disinclined to provide researchers with valid information on factors affecting the health and safety of migrant workers. Moreover, some migrant construction workers may attempt to hide injuries or incidents to avoid termination of their employment (Machado Susseret et al., 2019). Many construction companies will use financial incentives to motivate migrant workers who can maintain an injury-free record or exhibit outstanding safety performance within predetermined time frames (Wei et al., 2012). This practice will further deter migrant workers from reporting actual injuries or incidents, as they may be afraid of losing the financial incentives (Gangwar and Goodrum, 2005).

2.1.3 The importance of systematic literature review on multiple influencing factors

In summary, at the preliminary stage of this study, it is necessary to clarify the following research questions: What are the different definitions of migrant workers? What influencing factors are specific to migrant construction workers? How do these influencing factors affect the health and safety of migrant workers in the construction industry?

Although there are literature reviews on the occupational safety of migrant construction workers, most have focused on the relationship between safety and a single influencing factor, such as illness or

environmental conditions (Acharya et al., 2018), language barriers (Lindhout et al., 2019), or safety training (Peiró et al., 2020). Hence, to address this research gap, a systematic literature review of multiple influencing factors was conducted in the preliminary stage.

2.2. Methodology

2.2.1. Review method and selection rationale

The research methodology conducted in this systematic literature review is a quantitative approach named the 5-step method that was proposed by Khan et al. (2003), Thielen et al. (2016), and Wijnen et al. (2016). Based on the detailed introduction of the 5-step method by these researchers, an innovative enhancement was made in this study by incorporating the 5-step method and the Systematic Reviews and Meta-Analyses (PRISMA) This enhancement improves the original methodological framework. The 5-step method has both similarities to and differences from the PRISMA. Both review analysis methods that require researchers to utilise multiple databases to ensure a sufficient amount of candidate literature (Khan et al., 2003). In addition, both these two review methods provide valid analysis and assessment of scientific reports or studies in a specific field of research (Selçuk, 2019). However, the 5-step method could be regarded as a simplified version of PRISMA. The 5-step method provides a more intuitive approach for researchers to understand how to effectively screen and review the existing literature (van Mastrigt et al., 2016). In the 5-step method, multiple screening is used to ensure the accuracy of a systematic literature review (Tacconelli, 2010). Furthermore, in contrast to PRISMA, the 5-step method places greater emphasis on summarising and analysing a broader range of literature (Yoong et al., 2022). The specific 5-step operation flow chart is shown in Figure 2.1.

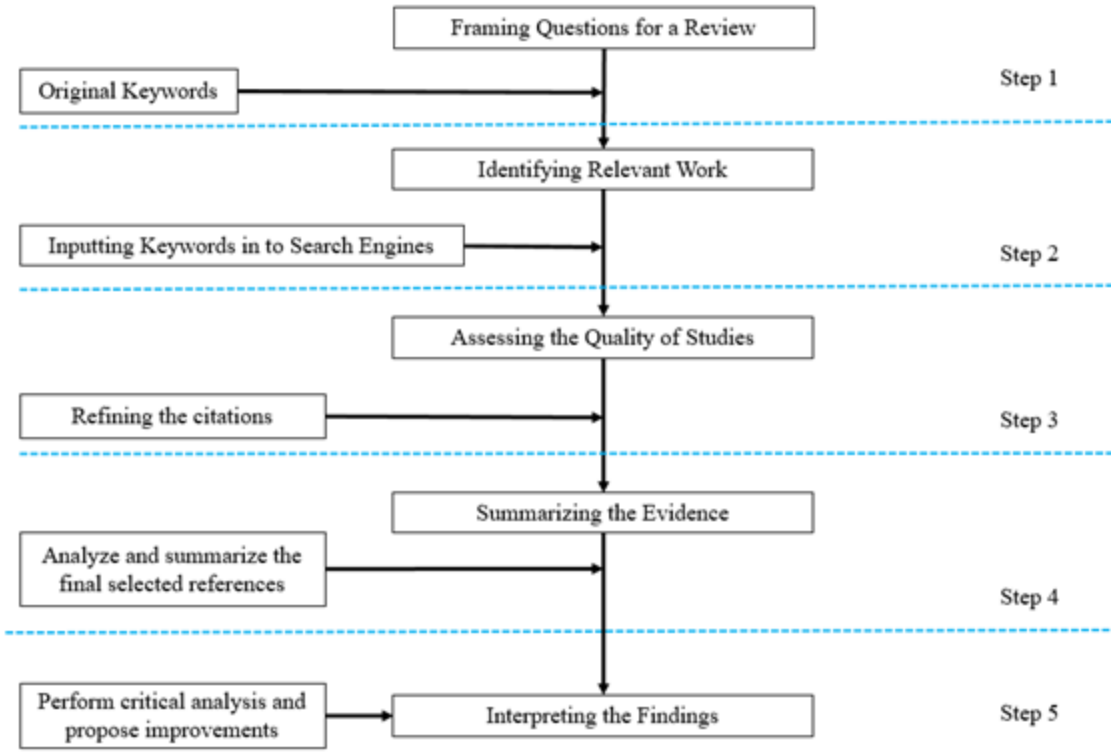

Figure 2.1. Steps for conducting a systematic literature review

2.2.2. Details of 5-step method

According to Khan et al. (2003), this systematic literature review method can be divided into five steps: Step 1: framing questions for a review, Step 2: identifying relevant work, Step 3: assessing the quality of studies, Step 4: summarising the evidence, and Step 5: interpreting the findings.

The first step is to identify clear, unambiguous, and structured questions (Khan et al., 2003, Thielen et al., 2016, Wijnen et al., 2016). This step can be achieved by dividing the research topic into multiple research questions and then addressing these questions by systematic reviews (Hempel, 2016). The second step is to search for various resources without language limitations (Khan et al., 2003). In this step, it is necessary to utilise plural keywords to narrow the scope of the literature review (van Mastrigt et al., 2016, Lu and Liu, 2014). The purpose of this scoping review is to examine whether any similar studies have been published or are underway in the international literature (Booth et al., 2012). The scoping review could determine the overall volume of literature that needs to be reviewed and analysed.

In the third step, all the publications searched in step 2 need to be screened based on particular criteria. This step is the core step in the systematic literature review as it needs to extract and refine the key information from the research materials in step 2 that will be beneficial for improving the structured overview of research topics (Hempel, 2016). This step should be divided into two stages (Tacconelli, 2010). In the first stage, researchers must conduct an initial visual examination of the literature's title, abstract, and keywords (Ke et al., 2009, Tacconelli, 2010). This helps researchers quickly filter out literature that does not align with the research objectives (van Mastrigt et al., 2016). At this stage, it is necessary to eliminate literature with different research directions or not containing all keywords. Duplicate literature from different databases should also be removed by software such as EndNote, or manually deleted (van Mastrigt et al., 2016). The second stage is to conduct a full-text review. The screening criteria in this systematic literature review are shown below:

1) Published literature published between 2000 and 2022,
2) The type of the literature should be "article",
3) The language of the literature should be "English",
4) The literature should be consistent with the research direction.

Step 4 is to integrate and distinguish differences between the remaining references (Susanne et al., 2016). The relevant information from the remaining literature, consistent with the research objectives, needs to be aggregated and categorized in detail (Lu and Liu, 2014). Data-based research results can provide readers with a more intuitive understanding of the research progress and the status of the research field (van Mastrigt et al., 2016). The final step is to interpret the review findings. It is necessary to summarise and analyse the research results and propose a plausible explanation for them.

2.3. Results

According to the flow chart shown in Figure 2.1, there are five steps in this systematic literature review, with the detailed procedures and search results outlined for each step.

2.3.1. Result of step 1

This study explores the health and safety of migrant workers in the construction industry. The following research questions could be derived from this topic:

1) Who are migrant construction workers?
2) Which factors will impact the health and safety of migrant construction workers?
3) What are the differences between influencing factors that impact migrant workers compared to native workers in the construction industry?
4) What are the current strategies for addressing health and safety risks faced by migrant workers?

The research objective of the systematic literature review is to explore the definition of migrant construction workers and determine the factors affecting the health and safety of migrant construction workers. According to the aforementioned research questions, the essential keywords for this systematic literature review are summarised in the next step. It is worth noting that the term "migrant" and related variations like "immigrant" or "emigrant" need to be considered to expand the scope of the literature review.

2.3.2. Result of step 2

Based on the research questions in the step 1, the keywords in this systematic literature review were 'Health' AND 'Safety' AND 'Migrant OR Immigrant OR Emigrant' AND 'Construction'. All these keywords were inputted into bibliographic databases to retrieve all potentially relevant existing literature. This study used two authoritative search engines, the Web of Science and Scopus, to improve the diversity of the literature and reduce biased literature. The search field and date range were 'Title or Abstract or Keywords' and "from 2000 to 2022". After the preliminary search, 136 and 89 articles were identified on the Web of Science and Scopus, respectively.

2.3.3. Result of step 3

The step and results of the literature screening are shown in Figure 2.1. First, 55 duplicate publications were automatically deleted. Second, due to non-compliance with criteria 2 and 3, 42 extracts from the literature were eliminated. Third, based on the review of abstracts and full-text, 61 articles were excluded. Among these articles, some did not simultaneously explore the three main keywords of "migrant workers", "construction industry" and "security risk". Additionally, some articles lacked a discussion on international migration. Thus, after all non-relevant studies were deleted from the search, 60 identified articles were included in this systematic literature review.

2.3.4. Result of step 4

Table 2.1 summarises the characteristics of the 60 identified articles according to the directions of "*Fields of Study"* and *"Country".* Figure 2.2 classifies the 60 identified articles by *"Time Span"*.

Table 2.1. Classify the 60 identified articles in "Fields of Study" and "Country".

Fields of Study	Frequency # Of paper (out of 60 identified articles), %	Country	Frequency # Of paper (out of 60 identified articles), %
Public Environmental Occupational Health	38, 63.3%	United States	29, 48.3%
		United Kingdom	9, 15.0%
Engineering	14, 23.3%	European countries	9, 15.0%
		Singapore	4, 6.7%
Construction Building Technology	5, 8.3%	China	3, 5%
		United Arab Emirates	2, 3.3%

Environmental Sciences Ecology	5, 8.3%	Korea, India, Nepal, and Saudi Arabia	1, 1.7%
Operations Research Management Science	4, 6.7%		

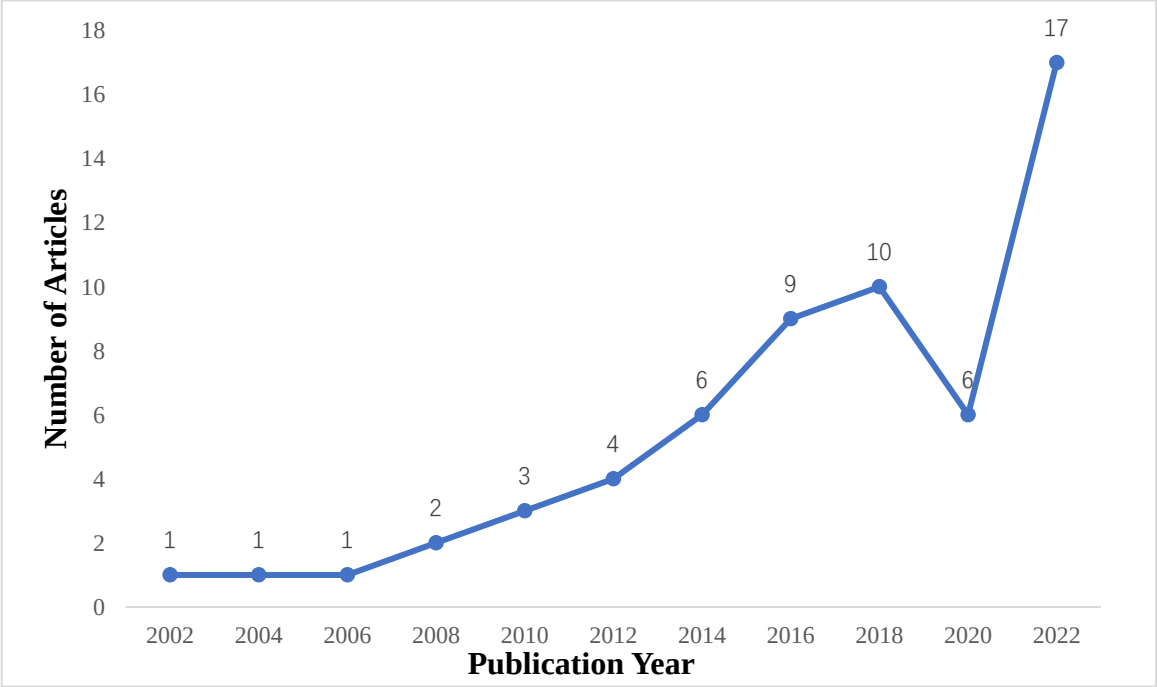

Figure 2.2. Classified by time span.

It can be seen from Table 2.1 that the field of study with the highest proportion is 'Public Environmental Occupational Health', accounting for 63.3% of the identified articles. The second-ranked field of study is "Engineering" (23.3%). Since an article can cover multiple research fields, the total frequency does not sum to 100%. Moreover, this systematic literature review also categorized the 60 identified articles based on the country of publication or the country in which migrant construction workers worked. Most studies were conducted in the United States (29 out of 60 identified articles). The second-ranked regions were the United Kingdom and European countries (9 out of 60 identified articles). Some articles discussed migrant construction workers in Singapore (4 articles), PRC (3 articles), and the United Arab Emirates (2 articles). There was one article each on the health and safety of migrant construction workers in Korea, India, Nepal, and Saudi Arabia. According to Figure 2.2,

the number of articles on the health and safety of migrant construction workers shows a generally increasing trend. The number of articles available for review from 2021 to 2022 increased dramatically, reaching 17 publications. This represented nearly triple the number of articles in the previous period.

2.3.5. Result of step 5

This systematic literature review summarised the definition of migrant workers and the influencing factors impacting the health and safety of migrant construction workers. Table 2.2 shows the definitions of migrant workers from the 60 identified articles. It can be seen that different countries or regions have different recognition of who can be regarded as “migrant workers”. Upon reviewing these articles, it can be found that there are differences in the definition of the terms "migrant workers" and "immigrant workers".

Table 2.2. Description of migrant and immigrant workers

Geographic Location	Definition	References
The United States (US)	Foreign-born workers are non-U.S.-born workers but live in America. Foreign-born workers could include immigrants, refugees, and temporary residents.	(Cruz et al., 2018)
	Non-native workers usually refer to Latino or Hispanic immigrants born in Latin America but live in the United States.	(Cunningham et al., 2018)
	Immigrant workers refer to Latino, Hispanic or Mexican workers living in America permanently.	(Arcury et al., 2014, Arcury et al., 2012, Arcury et al., 2015, Chávez and Altman, 2017, De Jesus-Rivas et al., 2016, Dong and Platner, 2004, Dong et al., 2007, Dong et al., 2009,

		Fernández-Esquer et al., 2020, Forst et al., 2013, Grzywacz et al., 2012, Díaz Fuentes et al., 2016, Ibarra-Mejía et al., 2021, Lin et al., 2018, Marin et al., 2015, O'Connor et al., 2005, Pransky et al., 2002, Rabito et al., 2011, Teran et al., 2015) (Welton et al., 2018) (Welton et al., 2020, Williams et al., 2010, Lara et al., 2021)
The United Kingdom (UK)	Migrant workers refer to people who come from other countries to find work opportunities. These migrants are also called international migrant workers.	(Adhikary et al., 2018, Bust et al., 2008, Hare et al., 2013, Hassanein and Hanna, 2008, Meardi et al., 2012, Oswald et al., 2018, Pink et al., 2010, Shepherd et al., 2021, Vignoli et al., 2021)
PRC	Migrant workers are farmers from rural areas seeking better employment opportunities in urban areas. These migrants are internal migrant workers.	(Wang et al., 2016, Chan et al., 2016)
	In Hong Kong, ethnic minority workers refer to migrants who are from Nepal, Pakistan, Thailand, and Philippines.	(Lyu et al., 2018)
Australia	Scholars in Australia always use “migrants” to refer to people migrating from other countries.	(Oswald et al., 2019)
European countries	Immigration refers to migration to another country to settle permanently. The technical definition of	(Giraudo et al., 2017, Martínez-Rojas et al.,

	migration requires people to reside abroad for over a year.	2022, Ricci et al., 2021, de Diego-Cordero et al., 2021)
	Most migrant workers are mainly from another European Union (EU) member state.	(Wasilkiewicz et al., 2016)
Singapore	Migrant construction workers in Singapore are from overseas countries such as PRC, Bangladesh, India and Myanmar.	(Goh and Binte Sa'Adon, 2015, Dutta, 2017, Gan and Koh, 2021)
India	The term, "migrant construction workers" in India, usually refer to people who comes from rural area to urban city.	(Betancourt et al., 2013)
South Korea; United Arab Emirates (UAE); Argentina; Saudi Arabia	Migrant workers are individuals who travel to other countries to find a temporary job.	(Kim et al., 2020, Sonmez et al., 2011, Hussain et al., 2020, Machado Susseret et al., 2019, Mosly and Makki, 2021, Gurung et al., 2021, Afzal and Shafiq, 2021)

The complexity of defining migrant workers was affected by different statistical methods or migration policies implemented by different countries or regions (Simmons, 1987). Different regions or countries used different terms to define or describe migrant workers. For instance, in the US, immigrant workers are specifically designated as Latino or Hispanic workers from Mexico or South America living in America permanently (Welton et al., 2020, Ibarra-Mejía et al., 2021). In other regions like UK, Australia and Singapore, workers who come from other countries to find work opportunities in the construction industry are defined as migrant construction workers (Vignoli et al., 2021, Oswald et al., 2019). Countries with large populations like PRC (1,443 million) and India (1,395 million) usually define migrant workers as individuals moving from rural areas to urban areas to take temporary work

(Jiang et al., 2020). This migration process belongs to internal migration (Chan et al., 2016). This study does not address the internal migrant worker.

In addition, after reviewing the 60 identified articles, influencing factors which will affect the health and safety of migrant construction workers were classified into personal, organizational, and cultural factors. All these specific influencing factors affect migrant construction workers and are summarised in Table 2.3.

Table 2.3. Health and safety influencing factors for migrant construction workers

Health and Safety Risks Factors and their Descriptions	**References**	**Frequency** # Of paper (out of 60 identified articles), %
Personal Factors (micro-level) **Lack of safety awareness**		
Unwilling to comply with complex and formal safety regulations	(Arcury et al., 2014, Chávez and Altman, 2017, Hassanein and Hanna, 2008, Ricci et al., 2021, Shepherd et al., 2021)	11, 18.3%
Migrant workers from different region may have different risk attitudes		
Low awareness on wearing Personal Protective Equipment (PPE)	(Arcury et al., 2014, Goh and Binte Sa'Adon, 2015, Welton et al., 2020, Ibarra-Mejía et al., 2021)	
Exchange high risks for higher profits or turnover	(Arcury et al., 2012, Meardi et al., 2012, Oswald et al., 2018)	
Personal Factors (micro-level) **Limited education level**		

Migrant construction workers have a low level of education	(Díaz Fuentes et al., 2016, Fernández-Esquer et al., 2020, Kim et al., 2020, Lin et al., 2018, Meardi et al., 2012, Oswald et al., 2019, Teran et al., 2015)	7, 11.7%
Personal Factors (micro-level) **Poor psychosocial wellbeing**		
The mental stress of migrant construction workers due to racial or cultural differences, such as supervisor pressure, competitive pressure, employment pressure, heavy workload, and long working hours	(Adhikary et al., 2018, Arcury et al., 2012, Grzywacz et al., 2012, Marin et al., 2015, Teran et al., 2015, Welton et al., 2020)	6, 10%
Cultural Factors (meso-level) **Language Barriers**		
Language barriers refer to a kind of communication barrier caused by the difference between the first language and the destination language of migrant workers. It could be the biggest problem faced by migrant workers when working in a non-native language environment.	(Arcury et al., 2015, Afzal and Shafiq, 2021, Chan et al., 2016, Chan et al., 2021, Cruz et al., 2018, De Jesus-Rivas et al., 2016, Díaz Fuentes et al., 2016, Dong and Platner, 2004, Fernández-Esquer et al., 2020, Forst et al., 2013, Hare et al., 2013, Hussain et al., 2020, Ibarra-Mejía et al., 2021, Kim et al., 2020, Lin et al., 2018, Marin et al., 2015, Martínez-Rojas et al., 2022)	33, 55%

Cultural Factors (meso-level) **Cultural differences**		
Not adapting to the local working or living environment due to cultural differences	(Diana M et al., 2021, Ibarra-Mejía et al., 2021, Kim et al., 2020, Lin et al., 2018, Rabito et al., 2011, Teran et al., 2015, Wang et al., 2016, Wasilkiewicz et al., 2016, Welton et al., 2018)	9, 15%
Organizational Factors (macro-level) **Unfair policies or regulations**		
Unreasonable regulations that favour domestic employers	(Díaz Fuentes et al., 2016, Dutta, 2017, Gurung et al., 2021, Sonmez et al., 2011)	4, 6.7%
Organizational Factors (macro-level) **Low health and safety standards**		
The construction safety levels of the country of departure are lower than those of the destination country	(Dong et al., 2009, Goh and Binte Sa'Adon, 2015, Mosly and Makki, 2021, Welton et al., 2020)	4, 6.7%
Organizational Factors (macro-level) **Inferior quality of safety training**		
Short training period	(Afzal and Shafiq, 2021, Cruz et al., 2018, Cunningham et al., 2018, de Diego-Cordero et al., 2021, De Jesus-Rivas et al., 2016, Fernández-Esquer et al., 2020, Gan and Koh, 2021, Gurung et al., 2021, Hussain et al., 2020, Ibarra-Mejía et al., 2021, Lara et al., 2021, Lin et al., 2018, Meardi et al., 2012, Pink et al., 2010, Rabito et al., 2011, Ricci et al., 2021, Shepherd et al., 2021,	21, 35%
Simple training mode and teaching content		
Lack of bilingual teaching or training materials in the native language of migrant workers		

	Teran et al., 2015, Vignoli et al., 2021, Williams et al., 2010)	
Organizational Factors (macro-level) **Exploitation due to incomplete safety policies**		
Exploitation of employment rights, medical security rights, and wage income	(Ibarra-Mejía et al., 2021, Meardi et al., 2012)	11, 18.3%
Employers may use unemployment, repatriation or loss of future employment opportunities to coerce migrant workers into performing high-risk tasks	(Arcury et al., 2012, Betancourt et al., 2013, Bust et al., 2008, Díaz Fuentes et al., 2016, Giraudo et al., 2017, Marin et al., 2015, Oswald et al., 2018, Shepherd et al., 2021, Teran et al., 2015)	

According to Table 2.3, there were nine main influencing factors that could impact the health and safety of migrant workers in the construction industry, and all these factors can be summarised into three levels: personal factors (micro-level), cultural conflict factors (meso-level), and organizational factors (macro-level). This study categorizes the factors related to safety awareness, education level, safety behaviour, or psychological status of migrant workers as micro-level. The meso-level categorizes the factors into language barriers and cultural differences. At the macro-level, influencing factors include safety laws, safety policies, and safety training for migrant construction workers in the destination regions.

2.4. Discussion

Based on the systematic literature review, this study summarises the existing definitions of migrant workers in the construction industry, and these formed the theoretical foundation for an encompassing definition of CMCWs. The study also classifies nine different influencing factors impacting the health and safety of migrant construction workers.

2.4.1. Definition of CMCWs

Currently, the definitions of migrant workers are ambiguous (International Organization for Migration (IOM), 2019b). Different researchers (e.g. Hassanein and Hanna, 2008, Meardi et al., 2012, Shepherd et al., 2021)) used ‘migrant’ or ‘immigrant’ interchangeably to indicate foreign workers who came from other countries or regions to find job opportunities in the receiving countries. Readers, however, may be misled by the interchangeable use of these terms as there is a difference between these two terms.

The terms ‘immigrant workers’ and ‘emigrant workers’ have different meanings. As per the International Organization for Migration (IOM) and the International Labour Organization (ILO), although both terms ‘immigrant workers’ and ‘emigrant workers’ describe a person moving to another country to find a job, the former emphasizes workers moving into other countries and the latter indicates individuals moving away from their home country. ‘Migrant workers’, as a neutral term, is not limited by the direction of movement. However, the existing literature presents controversial viewpoints on how to distinguish ‘migrant workers’ from ‘immigrant workers’. For instance, the difference between ‘migrant workers’ and ‘immigrant workers’ is that the former frequently move back and forth between the original country and the host country, whereas the latter have largely assimilated or integrated into the host country.

According to the International Labour Organisation (ILO) (2021), migrant workers are people who are employed or unemployed foreign-born persons who are of working age in the current country of residence. In addition, there are various ways to interpret ‘migrant workers’ such as by visa type, length of residence/work, or place of origin, autonomy and legitimacy (King et al., 2008). Therefore, in the definition of CMCWs, the following aspects should apply:

Firstly, the most fundamental distinction among migrant workers is the division between internal and external migrants (King et al., 2008) based on their migration regions. Based on the results of the systematic literature review, the migration of CMCWs in PRC is internal migration; that is, rural dwellers who move to urban areas for temporary construction work (Yuan et al., 2009, Chan et al., 2016). Migration between countries is external migration or overseas migration (O'Reilly, 2012). Different scholars have different definition for overseas Chinese migrants. For instance, new Chinese migrants in NZ are Chinese groups from Hong Kong, Taiwan, PRC, and other countries like Malaysia or Indonesia (Liu and Lu, 2015). In Montenegro, overseas Chinese construction workers refer to Chinese ethnic groups from mainland China (English et al., 2021). In addition, some scholars have emphasised certain differences between Chinese migrant workers and overseas Chinese of other nationalities.

Secondly, some studies highlighted the length of residence/work and the types of visa of Chinese migrant workers. Rotimi et al. (2021) defined Chinese migrant workers as Chinese ethnic groups who hold temporary working visas. Yin (2015) defined Chinese migrant workers as immigrants who have been in NZ for over 12 months. Kalir (2009) defined Chinese migrant workers as individuals with temporary worker status, holding work visas valid for a maximum of five years.

Thirdly, illegal immigrants and refugees also belong to overseas migrants (Douglas et al., 2019). However, this thesis excludes these two categories of migrants as it proved challenging to gather meaningful information about these groups.

Therefore, CMCWs in this thesis belong to international migrants who possess Chinese citizenship who may face a higher risk of injury. To ensure a sufficient data resource, this thesis does not restrict the type of visa and the length of work/residence. This means that the sample group in the whole study also include ethnic Chinese workers from different countries such as Singapore or Australia. The sample group for this thesis consists of individuals who voluntarily migrated to host countries and hold legal contracts in the local construction industry. In addition, Chinese workers who transitioned out of construction work are categorized as Chinese migrant workers rather than specifically as CMCWs. The scope of this thesis is limited to CMCWs as its research subjects. Consequently, CMCWs are defined as *"migrant workers who have Chinese citizenship and have legal work in the construction industry outside of their country of origin."* The characteristics of CMCWs for this study should meet the following three aspects:

1) The sample group has a valid Chinese passport, including mainland Chinese passports, Hong Kong passports, Macau passports, and Taiwanese passports,
2) The sample group has a legal visa outside of their country of origin, and
3) The sample group has a current signed contract in the construction industry.

2.4.2. Special influencing factors affecting migrant workers' health and safety.

Numerous research investigations have demonstrated that migrant construction workers face a higher likelihood of suffering incidents than native construction workers (Cao et al., 2021, Chávez and Altman, 2017, Ibarra-Mejía et al., 2021, Lyu et al., 2018, Smith et al., 2022). Although construction work may pose an equal risk of incident for both migrant workers and native workers, migrant construction workers may take more risks or experience more severe consequences due to specific influencing factors. For instance, both migrant and native workers may share some common risk factors like slips, trips and falls on the construction sites (United States Bureau of Labour Statistics, 2021). However, migrant workers may face higher incident risks due to a language barrier (Premji et al., 2023), lacking safety awareness (Lay et al., 2018), and unsafe behaviour (Kim et al., 2020). Based

on the systematic literature review of the 60 identified articles, nine influencing factors are summarised in this study.

Some identified articles illustrated that the health and safety risks were directly caused by personal factors such as unsafe behaviour (Kim et al., 2020) or poor safety awareness (Ibarra-Mejía et al., 2021). Some migrant construction workers may resist safety regulations or wearing Personal Protective Equipment (PPE) as they believe that these protections will hinder their work efficiency (Goh and Binte Sa'Adon, 2015, Welton et al., 2020). In addition, migrant construction workers may exhibit overconfidence, believing that incidents will simply not happen to them (Arcury et al., 2014). The primary motivation of migrant workers in the construction industry is to increase earnings/savings swiftly. Therefore, many migrant construction workers endanger their lives in pursuit of this target (Meardi et al., 2012). However, inadequate safety awareness or limited education level also increase the risk of incidents for migrant construction workers (Chávez and Altman, 2017). For instance, it is reported that the number of fatal or non-fatal falling incidents for immigrant workers in the American construction industry was more than that for native construction workers due to a lack of adequate safety education (Cruz et al., 2018). These migrant or immigrant workers with low education levels cannot effectively apply their safety training in actual projects (Oswald et al., 2019). Moreover, poor psychosocial well-being or mental issues could also be regarded as a part of personal factors. Migrant construction workers are more likely to experience stress or work pressure because of discrimination (Fernández-Esquer et al., 2020). Stress or pressure may come from supervisors and colleagues (Welton et al., 2020), poor working and living conditions (Adhikary et al., 2018), lack of sleep caused by long hours of labour-intensive work (Jiang et al., 2020), and low wages (Al-Maskari et al., 2011).

In addition to personal factors, some health and safety influencing factors, such as exploitation due to incomplete safety policies, were classified into organizational factors (macro-level) after reviewing the 60 identified articles. It is worth noting that migrant construction workers themselves do not have the ability to change these organizational-level influencing factors. According to Dutta (2017), the exploitation of migrant construction workers was primarily linked to incomplete labour protection policies or discriminatory regulations in some countries. For instance, in the UAE, agencies used the kafala system to limit the right of migrant workers to freely choose their employer (Degorge, 2006). Due to regulations of this system, employers had the right to control the wages, passports, and living conditions of migrant workers (Adhikary et al., 2018). Many construction companies are not willing to hire migrant workers or force migrant construction workers to choose high-risk work with threats of job loss, repatriation, and loss of future employment opportunities (Giraudo et al., 2017, Ibarra-Mejía et al., 2021). Although most safety policy documents from construction companies demonstrated that they would provide safety training for migrant workers in advance, the content and effect of the safety training varies significantly; for example, differences in training methods, the length of training time, and the education level of the workers (Meardi et al., 2012). This undoubtedly increases the burden on migrant construction workers from different countries or areas who participate in host country safety training programs.

Cultural Factors (meso-level) are always regarded as the dominant factors influencing the health and safety of migrant workers in the construction industry (Seixas et al., 2012). Researchers have focused on the negative impacts of language barriers on the health and safety of migrant construction workers. As such, this study divides cultural factors into language barriers and cultural differences.

Firstly, language barriers can significantly hinder effective communication between migrant construction workers and their supervisors or native workers (Teran et al., 2015). These communication barriers can decrease work efficiency, extend working hours, and increase the probability of repeated work (Kim et al., 2020). Moreover, language barriers can lead to misunderstanding. For instance, migrant construction workers may be unable to respond to or avoid risks effectively due to language barriers, which can lead to fatal or non-fatal incidents (Al-Bayati et al., 2018). Migrant construction workers from several countries or areas constitute the main workforce on construction sites, especially in multinational projects (Oswald et al., 2019). In these multinational projects, while middle or senior manager can communicate in the language of the host country, verbal communication among migrant workers is complex and diverse, and can include many languages, such as Mandarin, Urdu, and Hindi (Afzal and Shafiq, 2021). Therefore, the commands or safety instructions have to be translated into multiple languages, which increases the possibility of errors and safety risks on construction sites (Afzal and Shafiq, 2021). Language barriers can also exist even between migrant construction workers from the same country of origin due to different dialects or multiple official languages. For instance, the Māori language and English are both used in the NZCI (Immigration New Zealand, 2019).

Secondly, language barriers can also affect the learning and application of knowledge gained during safety training (Arcury et al., 2012, Peiró et al., 2020). The current safety training manuals are often in the local official language rather than the native language of migrant workers (Chan et al., 2016). Therefore, misunderstandings or confusion regarding safety knowledge can arise for migrant construction workers with poor local language skills (Moyce and Schenker, 2018). Compared with native workers, migrant workers need to spend more time and energy becoming familiar with safety procedures, which decreases their motivation to participate in safety training (Preibisch and Otero, 2014). In addition, language barriers can diminish the training-transfer ability of migrant construction

workers (Oswald et al., 2019). This means that it is hard for many migrant construction workers to transfer the conceptual safety knowledge learned in safety training into practical workplace capabilities (Hussain et al., 2020).

2.5. Summary

The aim of the systematic literature review is to explore the definition of CMCWs and to summarise the existing influencing factors that can endanger the health and safety of migrant construction workers. This study used the 5-step method to review existing literature on the health and safety of migrant workers in the construction industry from 2001 to 2022. and 60 articles were finally identified as the analysis database. According to these 60 identified articles, this study generalizes the definition of CMCWs and nine influencing factors affecting the health and safety of migrant workers in the construction industry. Therefore, 'CMCWs' in this study refer to individuals who have Chinese citizenship and have legal work in the construction industry outside of their country of origin. The nine influencing factors are summarised and classified into three categories: organizational factors (macro-level), cultural factors (meso-level), and personal factors (micro-level). Among these influencing factors, personal factors like lack of safety awareness or limited education level can directly influence migrant workers' behaviour and eventually increase the risks of incidents. Organizational factors like exploitation or inferior quality of safety training can disenfranchise migrant construction workers and force them into high-risk occupations. Last but not the least, with respect to cultural factors, language barriers are regarded as the primary influencing factor for the health and safety of migrant workers in the construction industry. Language barriers will affect the communication between migrant workers and their supervisors or native colleagues. Due to language barriers, migrant workers are likely to face challenges in communicating effectively during emergencies, which can, in turn, elevate the risk and severity of injuries in incidents.

The next chapter explores solutions to improve the health and safety of migrant workers in the construction industry, such as audio or pictorial aids, bilingual managers, and visualization equipment.

It highlights that incentive strategies, particularly financial incentives, are the effective means to enhance workers' autonomous safety compliance.

CHAPTER 3

The impact of incentives on the safety performance of migrant construction workers: A scoping literature review

This chapter is based on the following unpublished manuscript, which has been submitted for journal review and consideration.

Guan, Z., Yiu, T.W., Samarasinghe, D.A.S., Ian Laird., and Reddy, R. Improving Health and Safety in Construction Workers through Incentive Strategies: A Systematic Literature Review.

Abstract

In the current construction industry, solutions such as audio or pictorial aids, employing bilingual managers, and using visualization equipment, can address the influencing factors of the health and safety of migrant workers. Among these safety improvement strategies, incentives are identified as the most direct and effective solution to enhance workers' autonomous safety compliance. This study reviewed journal articles published from 2004 to 2023 guided by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The results indicate that incentive strategies can be divided into positive incentives and negative incentives. Positive incentives can be further categorized into financial incentives (like bonuses or monetary benefits) and non-financial incentives (such as recognition, praise, or additional privileges), while negative incentives mainly consist of criticism and punishment aimed at discouraging undesirable behaviour or non-compliance with safety policies. The findings suggest that the provision of financial incentives is an effective strategy for enhancing the safety performance of CMCWs. Factors influencing financial incentives primarily stem from construction companies/clients, government support, and equitable distribution. Therefore, this study proposes the implementation of financial incentives to facilitate collaboration and communication among CMCWs, construction companies/clients, and governmental entities, thereby promoting safety performance on the construction sites.

3.1. Introduction

As discussed in the previous chapter, factors contributing to injuries and fatalities in the construction industry can include lack of safety training (Peiro et al., 2020), language barriers (Mosly and Makki, 2021), personal protective equipment (PPE) issues (Gurung et al., 2021), regulations loopholes (Sonmez et al., 2011) and lack of safety awareness (Chávez and Altman, 2017, Welton et al., 2020). Past research has explored a wide range of solutions to mitigate those influencing factors that have a negative impact on the health and safety of CMCWs in NZ (Han et al., 2020, Wu et al., 2022). For instance, one of the most common strategies to address the language barriers of migrant construction workers is to use visual equipment (Oswald et al., 2019). Construction companies also strengthen safety training for migrant workers (Dong and Platner, 2004, Mosly and Makki, 2021) or embrace automation technologies like Building Information Modeling (BIM) to minimize the risk of incidents on construction sites (Park and Kim, 2013, Riaz et al., 2014). Furthermore, various strict regulatory measures represent a fundamental step in improving the health and safety performance of construction projects (Oswald et al., 2018). However, certain studies have suggested that incentives, when compared to traditional regulatory measures, can lead to notable advancements in promoting the health and safety of construction workers (Onubi et al., 2021). Thus, incentive strategies can be regarded as a suitable method to improve the health and safety of construction workers (Zulkefli et al., 2014, Kim et al., 2022).

The utilisation of incentive measures has proven to be a more efficient strategy to promote the health and safety of migrant construction workers during the implementation of safety policies (Yang et al., 2021). In addition to incentives, punitive strategies are also used simultaneously in actual construction projects to ensure the effective implementation of safety policies or regulations (Zulkefli et al., 2014). Incentive or punitive measures are the most common technique to motivate the health and safety of construction workers (Sparer et al., 2015, Welles, 2022). However, the existing data on the impact of

Incentive/Punishment (I/P) on workers' safety performance is incomplete and inadequate, and, while numerous studies have explored the significance of incentive/punishment strategies in influencing migrant workers' safety performance, there remains considerable controversy among various scholars on the effectiveness of these two measures (Hasan and Jha, 2013, Sparer et al., 2015, Zulkefli et al., 2014).

This study has identified research gaps within this field by analysing existing literature articles to further explore the effectiveness of I/P strategies on the safety performance of migrant workers in the NZCI. Firstly, I/P strategies have not been the subject of studies but rather integral components of them (Alruqi and Hallowell, 2019, Supriyatna et al., 2020). For instance, while Supriyatna et al. (2020) recommended safety incentive programs as one of the measures to enhance the occupational health and safety of construction workers, their review paper only briefly discussed the safety incentive programs in the introduction section. The existing literature also suggests further analysis is needed specifically addressing the impact of incentives on the safety performance of construction workers (Alruqi and Hallowell, 2019, Supriyatna et al., 2020). Secondly, the scope of some literature reviews is limited to specific regions (Jaafar et al., 2018, Mohammadi et al., 2018). Thirdly, some literature review articles focused more on the effectiveness of I/P strategies during specific stages, like demolition (Aslam et al., 2020).

In summary, existing research gaps concerning incentives encompass a deficiency in secondary data investigations focusing on the life cycle processes of global migrant construction workers. This review narrows this research gap through a systematic literature review and focusing more on an examination of the influencing pathways and impact effectiveness of the I/P strategies on the safety performance of migrant construction workers. The scope of this review remains unrestricted in terms of geography

and construction stage. The objective of this study is to explore the incentive or punishment strategies that impact the safety performance of migrant construction workers, with a particular focus on identifying the mechanisms and effectiveness through which the strategies exert their influence. To achieve this aim, the following three research questions are posed in order to obtain research results:

1. What are the current incentive strategies available to improve the safety of migrant construction workers?
2. What are the effects of incentive strategies on improving the safety of migrant construction workers?
3. How can incentive strategies be improved?

3.2. Methodology

Systematic reviews and meta-analyses are rigorous studies and are popular ways to compile the available empirical evidence meeting a pre-defined set of eligibility criteria for a particular research hypothesis (Sohrabi et al., 2021). There are various advantages to the systematic literature review. For instance, a systematic literature review can provide a comprehensive and all-encompassing examination of the existing literature related to a research question. The systematic literature review can also be beneficial for strengthening the foundational knowledge of a specific topic while adhering to the principles of transparency and bias reduction (Williams et al., 2021). Moreover, systematic reviews and meta-analyses can offer the opportunity to critically assess and thoroughly aggregate the findings from multiple comparable trials, which can enhance the statistical power of the research (Sohrabi et al., 2021). This systematic literature review is based on PRISMA guidelines (Selçuk, 2019, PRISMA, 2021). PRISMA represents standardized and evidence-based guidelines that delineate the essential items for reporting in systematic reviews and meta-analyses. The PRISMA methodology is regarded as a valuable tool for the gathering of systematic quantitative and qualitative information concerning a research field (Prisma, 1983). The flow diagram below follows the guidance of PRISMA 2020 (Page et al., 2021). The process of PRISMA for this study is shown in Figure 3.1.

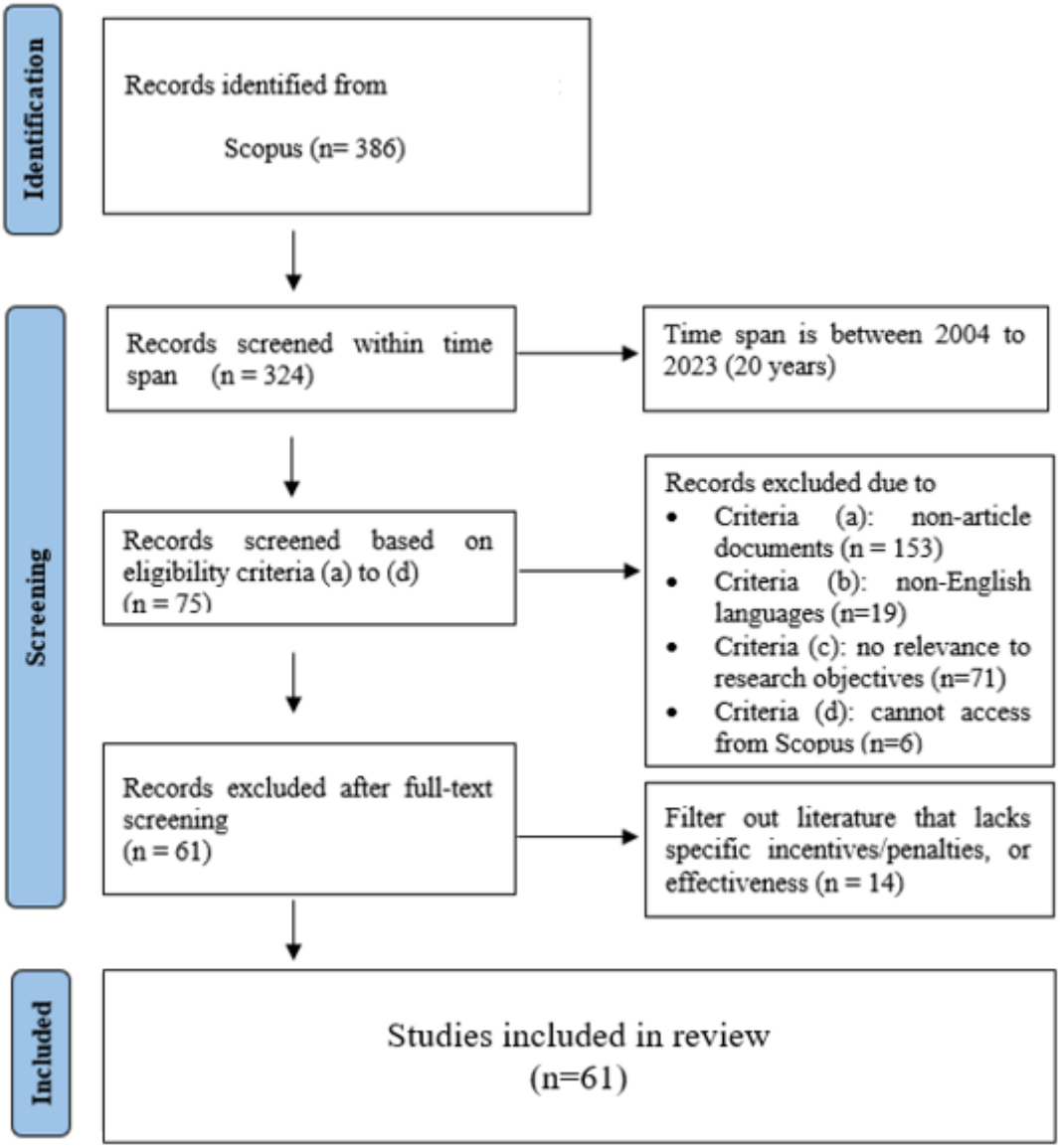

Fig. 3.1. Flow diagram based on PRISMA

Scopus was chosen as the primary database due to its extensive coverage, despite distinct differences in screening mechanisms when compared to Web of Science (Singh et al., 2020). The literature was pre-screened on Web of Science to prevent literature omission from using a single database. The pre-screening indicated that all the publications screened on Web of Science were available in Scopus. To enhance research effectiveness and minimise the need for repetitive screening and literature searches, only Scopus was used for the literature search. There was a comprehensive review and analysis of

published articles, government-issued reports, and existing regulations. All the government-issued reports and legislative documents were obtained through the official websites of different respective countries.

In order to accurately explore corresponding articles, various individual and combined keywords were used such as incentive, construction, and safety performance. The search strategy for Scopus was (TITLE-ABS-KEY ((incentive OR punishment)) AND TITLE-ABS-KEY (construction) AND TITLE-ABS-KEY (safety)). The TITLE-ABS-KEY refers to the title, abstract and keywords. It is worth noting that "migrant" was not added as one of the keywords selections. According to a pre-literature review, it was found that when "migrant" was added as a key word in Scopus, the results yielded only 4 documents. To broaden the database and ensure there was an adequate amount of data to support this systematic literature review, this study focused on the relationship between the I/P strategies and the safety performance of all construction workers, thus encompassing migrant construction workers. While the articles or reports/regulations collected in this chapter encompass a broader scope beyond migrant construction workers, Guo et al., (2018) has demonstrated that safety incentives have a more pronounced impact on migrant construction workers compared to other groups. To minimise the potential for bias, three independent reviewers checked all publications.

3.2.1. Search selection and eligibility criteria

All publications obtained according to keywords were double screened in this study. First, the titles and abstracts of the publications were screened for relevance. After the preliminary screen, eligibility for full-text reading was assessed. The screening criteria in this study are shown below. Publications were excluded if:

a) the published time was not between 2004-2023,

b) the document types were not journal articles,

c) the language was not English,

d) did not have full-text availability,

e) the articles did not have specific incentive/punishment method or effectiveness analysis.

3.2.2. Data extraction

The following relevant data was extracted from each eligible publication:

1) Lead author and year of publication,

2) Country/region of the population studied,

3) Specific incentive strategies,

4) Ways and effects of influencing safety performance.

3.3. Results

3.3.1. Basic results in time span and countries/territory

Overall, a total of 386 publications were obtained from the results of a keyword search from Scopus. After limiting the time span to nearly 20 years (2004-2023), 324 publications were assessed for eligibility. Of those, 153 publications not classified as "articles" were removed. Nineteen publications were eliminated as they were not written in English. Consequently, 84 articles relevant to the objectives of this research were selected after the first round of screening based on the literature abstracts. However, there were 6 documents that could not be accessed from Scopus as full articles due to access right limitations. Therefore, 75 publications were selected in the second screening. After a full-text review of the remaining articles, 14 articles were eliminated due to a lack of specific incentive/punishment methods or effectiveness analysis. Hence, 61 articles from Scopus were analysed and summarised in detail. The characteristics (the first author's name, publication year, specific incentive strategies, and effectiveness analysis) of the 61 identified articles are shown in Appendix 1

The study analysed 61 articles and classified them based on their time span and countries/territory. The time span of the 61 articles regarding incentives for the safety of construction workers from 2004 to March 2023 showed a complex trend. The number of identified articles reached its peak in 2022 with 12 publications.

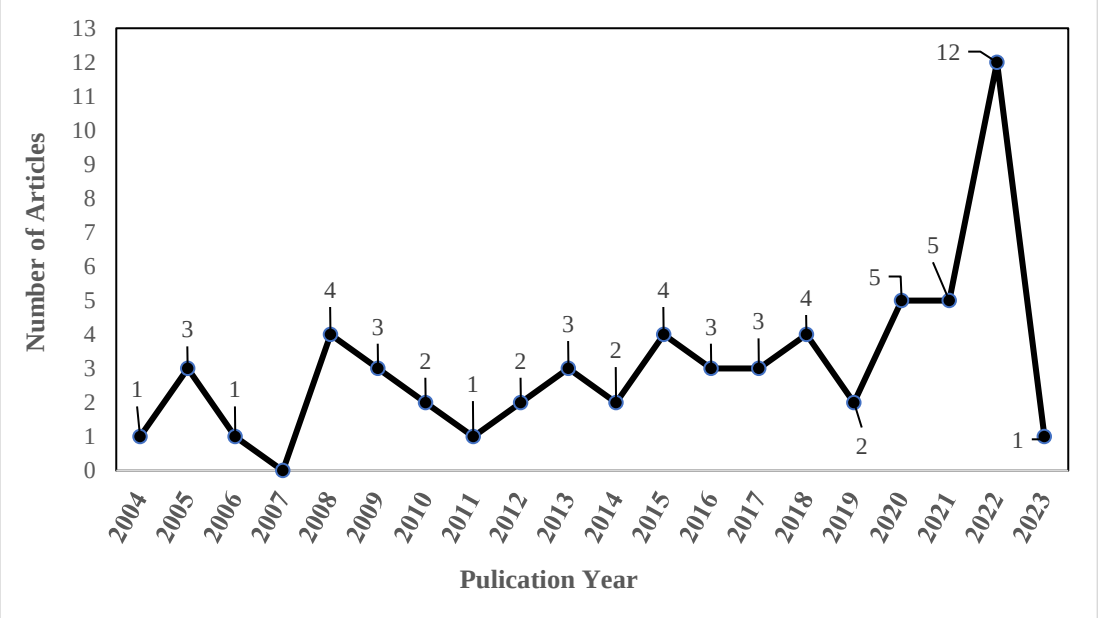

Figure 3.1. Classification of identified articles by time span. (*Source: Authors*)

The 61 identified articles came from 19 countries, including US (n=18), PRC (n=17), Singapore (n=5), Nigeria (n=3), NZ (n=2), UK (n=2), Australia (n=2), Pakistan (n=2), and one each from Denmark, South Korea, Brazil, Bangladesh, Malaysia, Thailand, India, Jordan, Egypt, Chile, and Iran.

3.3.2. General incentive strategies

Safety incentive strategies can broadly be divided into positive safety incentives and negative safety incentives which correspond to rewards and punishment approaches, respectively. There are numerous forms of safety incentive strategies and different safety incentive strategies can have different influences on construction workers' safety performance. This chapter provides an overview of the incentive and penalty strategies and discusses the effectiveness of these strategies on the safety performance of construction workers. Several safety incentive strategies are reported in Table 3.1.

Table 3.1. Classification of incentive strategies

Positive Incentives		
Specific Incentive strategies		References
Financial Incentives	Bonus/ prize/ gift/ coupon	(Abas et al., 2020, Afuye et al., 2022, Ahmed and Kabir, 2021, Ai Lin Teo et al., 2005, Ajslev et al., 2013, Brown and Barab, 2008, Campo et al., 2020, Chan et al., 2010, Gao et al., 2018, Ghasemi et al., 2015, Guo et al., 2018, Guo et al., 2021, Han et al., 2020, Hasan and Jha, 2013, Hassanein and Hanna, 2008, Hu et al., 2012, Ji et al., 2021, Jide et al., 2017, Kidd et al., 2004, Kim et al., 2019, Li et al., 2018, Lipscomb et al., 2013, Lucas et al., 2023, Mohammadi and Tavakolan, 2020, Molenaar et al., 2009, Pires, 2011, Shin et al., 2014, Sparer et al., 2015, Teo and Ling, 2009, Teo et al., 2005)
	Increased salaries/subsidies	(Egbelakin et al., 2022, Guo et al., 2021, Jide et al., 2017, Ning et al., 2022, Pires, 2011, Teran et al., 2015)
	Merchandise	(Ghasemi et al., 2015, Molenaar et al., 2009)
	Stock ownership/share	(Hosseinian et al., 2020, Liu et al., 2022b, Zulkefli et al., 2014)
Non-financial Incentives	Promotion	(Afuye et al., 2022, Ai Lin Teo et al., 2005, Ajslev et al., 2013, Gao et al., 2018, Hasan and Jha, 2013, Idoro, 2008, Li et al., 2018, Teo and Ling,

		2009, Teo et al., 2005, Zulkefli et al., 2014)
	Praise	(Ai Lin Teo et al., 2005, Ajslev et al., 2013, Han et al., 2020, Lucas et al., 2023, Mohammadi and Tavakolan, 2020, Sparer et al., 2015, Teo and Ling, 2009, Teo et al., 2005, Wu et al., 2022, Zhang et al., 2022, Zulkefli et al., 2014)
	All kinds of certificates/ awards/ reputation	(Abas et al., 2020, Ahmed and Kabir, 2021, Ai Lin Teo et al., 2005, Ajslev et al., 2013, Gao et al., 2018, Han et al., 2020, Ji et al., 2021, Li et al., 2018, Lipscomb et al., 2013, Mohammadi and Tavakolan, 2020, Teo et al., 2005, Idoro, 2008)
	Special assignments	(Zulkefli et al., 2014)
	Extra vacation	(Afuye et al., 2022, Teo and Ling, 2009, Ai Lin Teo et al., 2005, Sparer et al., 2015, Zulkefli et al., 2014)
	Increased autonomy	(Zulkefli et al., 2014)
	Religion-related rewards such as the establishment of prayer rooms or increased prayer breaks	(Ghasemi et al., 2015)
	Safety Mechanisms	(Guo et al., 2021, Ning et al., 2022, Guo et al., 2015, Zahoor et al., 2016, McDonald et al., 2009, Zahoor et al., 2017, Zhu and Cheung, 2021)
Negative Incentives		
Criticism	Oral or written reprimand	(Molenaar et al., 2009)

Punishment	Fines (monetary) or pay cut	(Abas et al., 2020, Afuye et al., 2022, Ahmed and Kabir, 2021, Ajslev et al., 2013, Brown and Barab, 2008, Egbelakin et al., 2022, Gao et al., 2018, Gray and Mendeloff, 2022, Guo et al., 2018, Hasan and Jha, 2013, Li et al., 2018, Lingard et al., 2019, Lipscomb et al., 2013, Liu et al., 2022a, Mohammad et al., 2010, Mohammadi and Tavakolan, 2020, Molenaar et al., 2009, Ning et al., 2022, Peng and Zhang, 2022, Teo and Ling, 2009, Teo et al., 2005, Teran et al., 2015, Wu et al., 2022, Zhang et al., 2022)
	Suspension from work	(Afuye et al., 2022, Ai Lin Teo et al., 2005, Gao et al., 2018, Teo and Ling, 2009, Teo et al., 2005, Lipscomb et al., 2013)
	Demotion (position- only applicable to supervisors)	(Afuye et al., 2022, Ai Lin Teo et al., 2005, Gao et al., 2018, Teo and Ling, 2009, Teo et al., 2005)
	Termination of employment	(Afuye et al., 2022, Ai Lin Teo et al., 2005, Brown and Barab, 2008, Gao et al., 2018, Molenaar et al., 2009, Teo and Ling, 2009, Teo et al., 2005)
	Reported to relevant authorities	(Ai Lin Teo et al., 2005, Gao et al., 2018, Lipscomb et al., 2013, Teo and Ling, 2009, Teo et al., 2005, Teran et al., 2015)
Monetary or prison penalty	(UK) • Health and Safety at Work etc. Act 1974	(legislation.gov.uk, 2022a, legislation.gov.uk, 2022b)

specified in the Acts/regulations	• The Construction (Health, Safety and Welfare) Regulations 1996	
	(Australia) Health and Safety Act 2011	(Federal Register of Legislation, 2018)
	(NZ) • The Building Act 2004 • HSW Act of NZ	(New Zealand Legislation, 2022, New Zealand Legislation, 2021)
	(Singapore) The Workplace Safety and Health (WSH) Act	(Minidtry of Manpower, 2023)
	(US) OSH Act of 1970	(United States Department of Labor, 2004)

Table 3.1 shows the specific classification of current mainstream safety incentive strategies. In general, safety incentives can be divided into positive incentives and negative incentives. Positive incentives entail the utilisation of material or non-material rewards as a method to motivate workers to autonomously improve their safety performance (Lingard et al., 2019). Negative incentives refer to the methods that compel workers to comply with safety compliance by imposing material or non-material penalties on those who contravene safety regulations (Gray and Mendeloff, 2022). Positive incentives include financial incentives like bonuses, increased salaries/subsidies, and stock ownership/share (Afuye et al., 2022, Chan et al., 2010, Egbelakin et al., 2022, Han et al., 2020, Gao et al., 2018), and non-financial incentives such as promotion, praise, or various kinds of certificates (Ai Lin Teo et al., 2005, Hasan and Jha, 2013, Wu et al., 2022, Mohammadi and Tavakolan, 2020).

3.3.3. Positive incentives

A positive incentive strategy provides specific rewards to individuals or all workers who maintain a record of no incidents or injuries during a specific timeframe (Gangwar and Goodrum, 2005, Hasan and Jha, 2013, Hinze and Gambatese, 2003). Positive incentives can be divided into two categories,

financial incentives and non-financial incentives (Zulkefli et al., 2014). Positive incentives aim to stimulate construction workers' intrinsic motivation and foster their voluntary compliance with safety policies/regulations, which can ultimately enhance workers' safety performance. The most common financial incentive is awarding bonuses to outstanding workers to motivate their adherence to safety compliance (Afuye et al., 2022). Bonuses can be provided in the form of prizes, gifts, or coupons (Chan et al., 2010, Egbelakin et al., 2022, Han et al., 2020). However, construction workers, including migrant construction workers, tend to prefer incentives such as increased salaries/subsidies (Guo et al., 2021). The management of a construction company can be incentivized through the co-sharing of stock ownership or shares (Liu et al., 2022b, Zulkefli et al., 2014). Promotion and encouragement are widely utilized non-economic incentives. Encouragement may be conveyed through verbal commendation or formal written recognition (Lucas et al., 2023). Written or oral praise is considered a necessary form of non-financial incentives (Afuye et al., 2022, Mohammadi and Tavakolan, 2020). It is best to give compliments in formal or public situations such as a company meeting, toolbox, or newspaper (Ghasemi et al., 2015, Hasan and Jha, 2013). This formal acknowledgement may not only motivate other workers to follow safety compliance requirements but also enable employees to repeat safety behaviour (Afuye et al., 2022). Last but not least, workers' traditional culture and religious beliefs should be respected when using incentives (Ghasemi et al., 2015); construction workers may be motivated to adhere to safety policies by incentives that respect and target traditional culture and religious beliefs, such as the establishment of prayer rooms or holding activities during their traditional festivals.

A total of 43 articles stated that positive incentives have a beneficial effect on improving the health and safety of construction workers. The research results on positive incentives are shown in Figure 3.2.

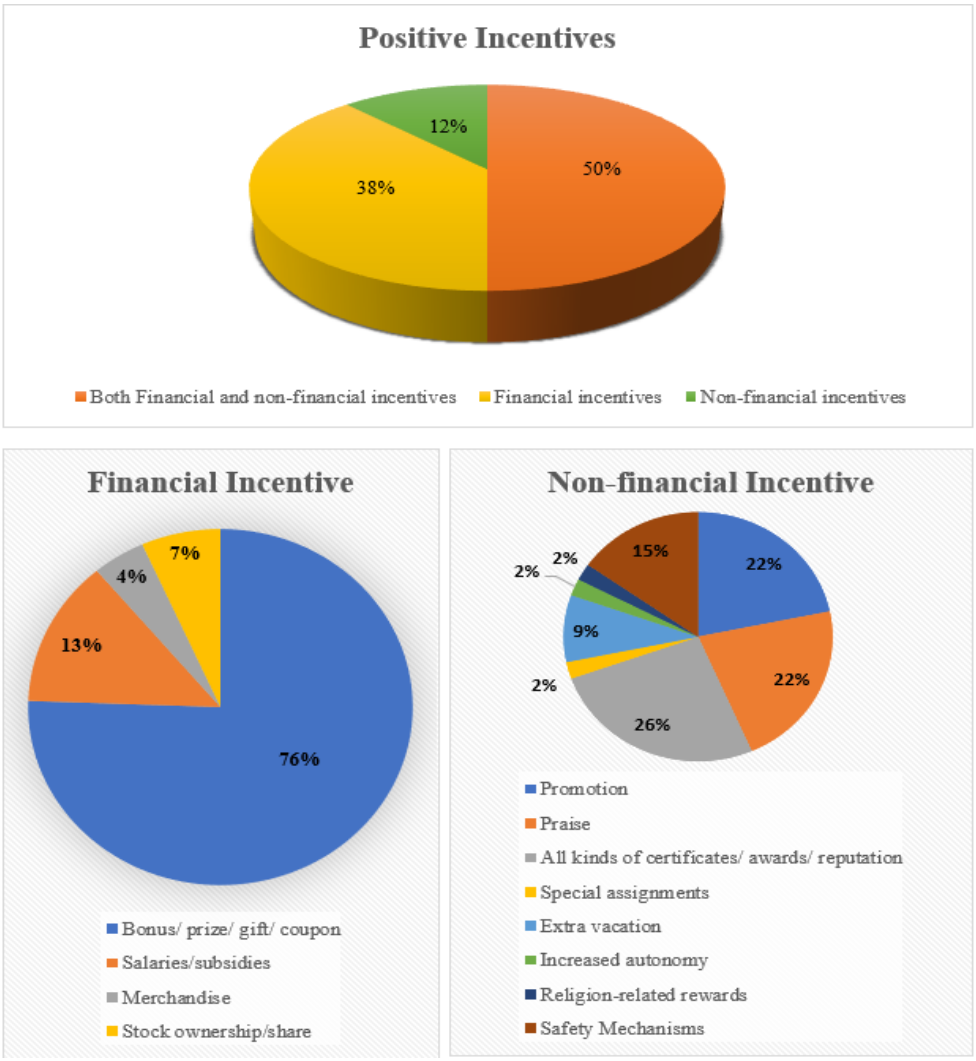

Figure 3.2. Percentage of the main type of positive incentives (*Source: Authors*)

It can be seen from Figure 3.2 that, among these articles, 50% advocated the adoption of a combination of financial and non-financial incentives. Approximately 38% of the identified articles focused more on the impact of financial incentives on the health and safety of construction workers. Meanwhile, 12% of these articles specifically delved into the methods and effectiveness of non-financial incentives. In addition, 76% of the identified articles support the utilisation of financial incentives, such as bonuses, gifts, or shopping vouchers, as substantial rewards for employees who excel in their performance. Other financial incentive strategies like motivating construction workers' safety performance through increasing salaries, merchandise, and stock ownership/share accounted for 13%, 7%, and 4%,

respectively. This indicates that direct material rewards are the most direct and effective method for improving the safety performance of construction workers. In contrast to the predominant presence of small bonus incentives within financial incentive strategies, the literature advocating for various types of non-financial incentives has a relatively evenly proportion of the incentive strategies. For instance, certificates, promotion, and praise emerge as the three most widely popular schemes among the various non-financial incentives, with 26%, 22%, and 22% respectively. Some construction companies may choose to assign special assignments or grant increased autonomy to workers with outstanding safety performance as a method to inspire other workers to enhance their safety behaviour and safety awareness. This strategy is not widely adopted, with only 2% of studies exploring its effectiveness. Moreover, (Ghasemi et al., 2015) proposed the implementation of non-financial incentives related to religion to motivate construction workforces, such as establishing prayer rooms or holding events during workers' traditional holidays. These incentives will improve employees' sense of identity in the company and motivate them to actively comply with the company's safety policies (Ghasemi et al., 2015).

3.3.4. Negative incentives

In addition to positive incentives, negative incentives are also recognized as commonly used incentives to enhance the safety performance of construction workers (Afuye et al., 2022, Gao et al., 2018, Hasan and Jha, 2013, Li et al., 2018). The findings on negative incentives are represented in Figure 3.3.

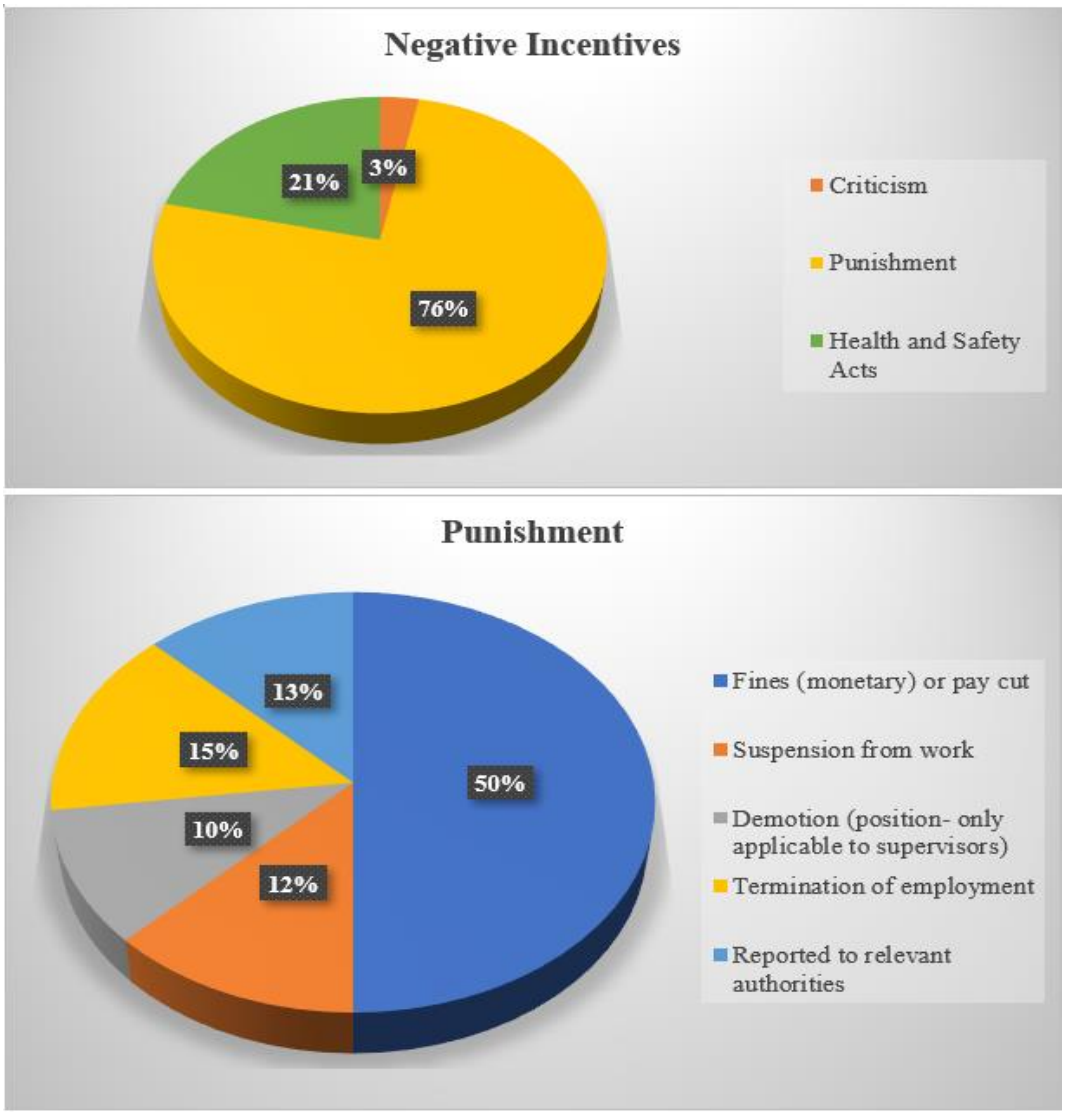

Figure 3.3. Percentage of various negative incentives (*Source: Authors*)

The performance strategies involving negative incentives can be categorized into the following groups based on the severity of a worker's violation:

a) Oral or written reprimand,

b) Fines

c) Suspension from work,

d) Demotion,

e) Termination of employment,

f) Reported to relevant authorities, and

g) Monetary or prison penalty specified in the Acts/regulations.

Figure 3.3 provides a visual representation of the proportion of research on various types of negative incentives in the selected source documents. Half of the identified articles have detailed investigations into fines as an effective negative incentive measure. Fines represent the most direct and uncomplicated negative incentive strategy and will be more effective for migrant construction workers whose primary objective is to earn money (Afuye et al., 2022, Guo et al., 2018, Zhang et al., 2022). Based on the previous analysis, negative incentives are one of the prevalent and essential strategies used in the current construction industry to deter construction workers, especially migrant construction workers, from contravening safety legislation. These negative incentives are implemented to discourage migrant construction workers from violating safety policies and regulations which are aimed to improve their health and safety awareness and practice. Compared with different legislative enforcement (21%) and criticism (3%), more scholars (76%) recommend punishment to regulate the safety compliance of construction workers. Figure 3.3 displays the distribution of various negative incentives that are extensively examined in the literature pertaining to punitive measures. The most common and fundamental kind of punishment strategy is fine (50%). With the gradual increase in worker infractions and the frequency of violations, the intensity of punishment has increasingly grown from fines (monetary), suspension from work (12%), demotion (10%), and termination (15%), and eventually to reporting to relevant authorities (13%).

3.4. Discussion

This literature review reports the incentives related to health and safety in the construction industry and the effectiveness of incentives on the safety performance of construction workers. The findings of this systematic literature review are equally relevant and applicable for evaluating the safety performance of migrant construction workers, given their substantial presence within this workforce. Incentive strategies play a vital role in improving workers' safety performance in the construction industry (Onubi et al., 2021, Teo and Ling, 2009, Zhang et al., 2022). Safety incentives refer to ways to motivate both native and migrant workers to comply with safety regulations and to give corresponding rewards or penalties based on their safety records (Fernando Alarcon et al., 2016, Gao et al., 2018, Ghasemi et al., 2015, Kim et al., 2019). Migrant construction workers, particularly Chinese migrant workers, relocate to countries like NZ in pursuit of better job opportunities and higher incomes (Liu, 2014). Incentives are the best solution to motivate CMCWs to comply with safety compliance requirements (Guo et al., 2023). Therefore, although the data collected in this chapter examines the effectiveness of incentives in improving the health and safety of all construction workers, the conclusions drawn are still applicable to CMCWs.

3.4.1. Effectiveness analysis

This systematic literature review not only outlines different types of incentive strategies but also analyses their effectiveness for migrant construction workers. Positive and negative incentives each have specific applications in the practical construction industry, but there are differing opinions on their actual impact. In addition, there are significant disparities in the effectiveness of financial and non-financial incentives in real construction projects.

3.4.1.1 Positive incentives vs Negative incentives

Existing research has demonstrated that construction companies should use negative incentives like punishments or penalties to strictly regulate the safety behaviours of construction workers (Teo and Ling, 2009, Gao et al., 2018). This viewpoint is supported by the majority of senior managers in large

or medium-sized construction companies (Afuye et al., 2022). It is implied that fines are regarded as one of the most commonly employed negative incentive strategies for improving the safety compliance and safety performance of migrant construction workers. For large and medium-sized construction companies with a significant workforce, fines serve as an efficient and transparent safety management strategy (Zhang et al., 2022). This negative incentive strategy can effectively conserve management time and effort (Jaselskis and Recarte Suazo, 1994). Therefore, although both negative and positive incentive strategies can decrease the incident rate, negative incentives possess more prominent advantages in improving the safety performance of construction workers and saving safety management costs (Ghasemi et al., 2015).

However, Tam and Fung (1998) hold a contrary view on this matter. An increasing number of scholars are beginning to direct their focus towards positive incentives and propose that positive incentives have a beneficial effect on motivating construction workers' safety awareness and compliance (Bradbury et al., 2018, Kim et al., 2019, Li et al., 2018, Teo and Ling, 2009, Zhang et al., 2022). This viewpoint breaks the conventional concept of incentives primarily relying on negative incentives such as fines. The advantage of positive incentives is to improve the subjective awareness of construction workers and motivate the workforce to cooperate with safety management on construction sites (Aksorn and Hadikusumo, 2008, Li et al., 2018, Teo and Ling, 2009). Positive incentives can not only contribute to reducing the injury rate in the construction industry to achieve zero incident management practices but can also help in effectively fostering a safety climate on construction sites (Ghasemi et al., 2015, Mohammad et al., 2010). In addition, positive incentive strategies can render construction workers more receptive to adhering to regulations or safety policies as well as encouraging them to proactively improve their own safety awareness (Ghasemi et al., 2015, Mohammad et al., 2010). Furthermore, positive incentives can enable workers to spontaneously resist unsafe behaviour and reinforce mutual supervision among construction workers (Aksorn and Hadikusumo, 2008). This

means that in situations where some workers within a construction team fail to adhere to safety policies, the positive safety incentives received by the entire team may decrease as the individual safety performance of certain workers deteriorates. Consequently, workers will monitor each other and consciously discourage those who do not comply with safety compliance in the interest of the overall team (Welles, 2022, Wu et al., 2022).

However, positive safety incentive strategies are still in an immature stage of research development (Fernando Alarcon et al., 2016). This systematic literature review not only consolidates the findings regarding the effectiveness of positive safety incentives on safety performance but also discusses the limitations associated with positive incentives. For instance, some researchers demonstrated that the effectiveness of positive incentives on the safety performance of construction workers is related to both the duration and intensity of the incentive strategies implemented (Afuye et al., 2022, Fernando Alarcon et al., 2016, Hinze and Gambatese, 2003). Firstly, there is evidence to indicate that a weak correlation exists between long-term positive incentives and construction workers' safety performance (McDermott et al., 2018). While positive safety incentives can effectively improve on-site workers' safety awareness and performance in the short term, the effectiveness and impact tend to diminish with time (Gangwar and Goodrum, 2005, Kim et al., 2019, Lucas et al., 2023). Research also shows that construction companies with positive safety incentives can showcase better safety records, but there is still a lack of substantial data to support this argument (Hinze and Gambatese, 2003). Therefore, it would be prudent to integrate both positive and negative incentives to create comprehensive and impactful safety incentive strategies.

3.4.1.2 Financial incentives vs Non-financial incentives

Construction workers or contractors anticipate more substantial financial incentives to motivate them to maintain exemplary safety performance (Chan et al., 2010). From the construction workers'

perspective, financial incentives are more likely to motivate their safety awareness of on-site hazards (Han et al., 2020). There is evidence that companies use income-sharing contracts to motivate workers' safety compliance; that is, the company promises that construction workers who meet or exceed a predetermined profit or target, can collect a certain amount of the overall project revenue (Liu et al., 2022b, Welles, 2022). However, in actual construction projects, large financial incentives are not always easy to implement, and numerous studies do not support this kind of financial incentive strategy (Teo and Ling, 2009). Construction companies are primarily focused on maximizing profits and are frequently reluctant to actively invest in financial incentives (Jide et al., 2017). Therefore, multiple small financial incentives are the effective measures to improve workers' safety performance (Han et al., 2020, Lucas et al., 2023). However, if the number of financial incentives is too large or extremely easy to obtain, the effectiveness of incentives will be diminished. It is difficult to quantify all safety behaviours (Geller, 1999, Teo and Ling, 2009) and for site managers to determine which individual workers' behaviours contribute to a positive on-site safety climate; it can be also difficult to reward various types of work equitably (Teo and Ling, 2009).

In addition, once financial rewards significantly outweigh construction workers' intrinsic motivation for safe practices, the effectiveness of safety incentives may be compromised (Lingard, 2001). Financial incentives will increase the risk of workers intentionally concealing injuries or incidents to obtain awards (Gangwar and Goodrum, 2005, Kim et al., 2019). Compared with financial incentives, non-financial incentives are regarded as more effective in reward and recognition (Zulkefli et al., 2014). Non-financial incentives, such as praise and promotions, can not only mitigate additional costs in the construction projects, but can also motivate workers to improve their safety awareness and performance (Teo and Ling, 2009). However, the effectiveness of non-financial incentives is not as good as that of financial incentives in actual projects (Chan et al., 2010). Hence, employing a balanced

combination of financial incentives and non-financial incentives represents the most effective incentive strategies for improving the safety performance of construction workers (Han et al., 2020).

3.4.2. Other factors affecting the effectiveness of safety incentives

The effectiveness of safety incentives is also influenced by several other factors. Firstly, migrant construction workers' motivation can be affected by the timing, location, and the types of incentives. For instance, certain incentives, such as praise and bonuses should be given immediately when construction workers show outstanding safety performance (Lucas et al., 2023). In addition, implementing safety incentives in formal or public settings, such as company meetings, toolboxes, or newspapers, can increase the effectiveness of safety incentive strategies (Ghasemi et al., 2015). This can not only motivate other workers to adhere to safety compliance requirements but also enable the rewarded workers to maintain their safety behaviours (Afuye et al., 2022).

Secondly, safety incentives not only increase safety awareness and performance among construction workers but also yield positive effects for both clients and contractors (Chan et al., 2010). Clients and contractors, as the individuals responsible for implementing construction site safety procedures, play a vital role in improving the health and safety of migrant construction workers (Onubi et al., 2021). According to the results of this systematic literature review, investment in health and safety shows a positive contribution to safety performance. However, there is a prevailing lack of motivation and awareness among clients and contractors to implement safety incentives on construction sites (Musonda and Pretorius, 2015). There are two strategies for motivating construction company executives. For instance, the hosting of safety inspection contests that combines penalties and rewards is conducive to top managers enhancing safety through greater planning, risk-free working practises and equipment, and improved staff training (Laitinen and Päivärinta, 2010). These contests include financial incentives (such as profit maximization or reducing construction costs) and non-financial

incentives like enhancing a company's reputation (Ninan et al., 2022). In addition, pay-for-performance schemes strongly incentivise bureaucrats to meet their performance targets (Pires, 2011). If the general construction contractor could meet all safety targets, it would receive a commendation certificate and a bonus of approximately 0.1–0.3% of the contract price, over and above the original competitive bid price (Pires, 2011).

Thirdly, the government can incentivize construction enterprises to strengthen safety and supervision standards by changing the tax rate of construction enterprises in the event of incidents (Liu et al., 2022a). Incentives such as flexible loans and rapid approval of compliant designs can encourage clients to comply with building codes and regulations (Ahmed and Kabir, 2021). A reward and punishment mechanism implemented by the government can encourage clients or contractors to provide safety education and safety training for construction workers and to promote active site supervision and management (Guo et al., 2021).

3.5. Conclusion

This chapter conducts a systematic literature review to evaluate the impact of safety incentives on the safety performance of migrant construction workers. The chapter provides a comprehensive overview of the various existing safety incentives and analysis the effectiveness of different safety incentives and the influencing factors that may affect the effectiveness of incentive strategies. The initial intention of this chapter was to focus on migrant construction workers as the research subjects. However, a significant lack of available literature data hindered the systematic review of these research subjects. According to the search results obtained from Scopus, there were only four articles related to safety incentives and the health and safety of migrant construction workers. Hence, to broaden the dataset this study expanded the research scope to encompass all construction workers. The research findings indicate that safety incentives are not only applicable to all construction workers but also have a substantial impact on enhancing the safety performance of Chinese immigrant construction workers.

PRISMA was used to analyse the effects of different incentive strategies on construction workers' safety performance in the 61 articles extracted from an authoritative database (Scopus). The time span of this review is from 2004 to 2023. According to the results of the systematic literature review, the literature on the impact of incentives on the health and safety of construction workers has grown in fluctuations over this time span. The largest number of identified articles is in 2022, reaching 12 publications. The majority of the identified articles come from PRC and the United States, which demonstrates that highly industrialising nations need incentives to boost construction workers' safety performance.

Analysis of the final 61 articles in this review suggests that the aim of incentives is to boost safety motivation among construction workers by offering rewards or implementing punishments to enhance safety compliance. Safety incentives can be divided into positive safety incentives and negative safety incentives. Negative safety incentives aim to reinforce the adherence of on-site construction workers to safety regulations through criticism or punishment. The negative incentives are regarded as typical strategies utilised by large companies and governments to maintain health and safety in the construction industry. However, research supporting the use of positive safety incentives has been growing. Positive safety incentives involve offering financial or non-financial rewards to motivate construction workers to voluntarily comply with safety regulations and to improve the overall safety climates on construction sites. However, positive incentives, especially financial incentives, have drawbacks. For instance, workers may obtain rewards by concealing incidents or injuries. The findings suggest that multiple small-scale financial rewards are the optimal strategy to improve the health and safety of migrant construction workers. It is worth noting that when employing financial incentives, non-financial incentives like praise or promotions should also be used to mitigate the risk of construction workers or contractors concealing incidents or safety reports in pursuit of financial incentives. Overall, the balanced implementation of both positive and negative safety incentives

constitutes an effective strategy to safeguard the health and safety of migrant construction workers. According to findings in section 1.3 in Chapter 1, CMCWs are a significant part of international migrant construction workers and are most likely incentivised as much as native workers. Hence, positive safety incentives motivate CMCWs' intrinsic enthusiasm, while negative safety incentives enhance the effective implementation of incentive strategies.

The next chapter expands of the literature review on incentives by investigating the relationships among five safety influencing factors (safety policy, safety training, communication barriers, cultural differences, and personal variables) on safety outcomes for CMCWs.

Chapter 4

The Interconnectedness of Safety Influencing Factors and Safety Outcomes: A Novel PLS-SEM Model. This chapter is based on the following unpublished manuscript, which has been submitted for scientific journal review and consideration.

Guan, Z., Samarasinghe, D.A.S., Yiu, T.W., Ian Laird., and Reddy, R. Investigating Factors Affecting Health and Safety Outcomes of CMCWs: A PLS-SEM Study.

Abstract

The previous chapters provide an overview of the influencing factors and potential solution strategies for enhancing the health and safety of CMCWs from a global perspective, as derived from a systematic literature review. The research reported in this chapter serves as a practical validation of the theoretical framework established based on the results of systematic literature reviews. This study investigates the intrinsic relationships among five safety influencing factors (safety policy, safety training, communication barriers, cultural differences, and personal variables) and safety outcomes among CMCWs. Data collection was conducted through questionnaires, and a structural equation model was established using the Partial Least Squares Structural Equation Modeling (PLS-SEM) method to assess the significance of each variable in the model. The findings from this chapter highlight that safety policies and personal variables have a statistically significant influence on safety outcomes. This conclusion, combined with the results of the questionnaire survey, indicates that knowledge of local safety policies and personal safety awareness among CMCWs can significantly impact their safety outcomes on construction sites. Essentially, a deeper understanding of safety policies or a stronger safety awareness contribute to a reduced risk of incidents among CMCWs. Hence, this chapter recommends strategies aimed at enhancing the health and safety of CMCWs by focusing on increasing their safety awareness and understanding of safety policies.

4.1. Introduction

In the construction industry, migrant workers represent one of the main workforce groups at risk of injuries and fatalities (Vignoli et al., 2021, Chávez and Altman, 2017, Grzywacz et al., 2012). There are many factors that affect the health and safety of migrant construction workers, and these present challenges to effective safety management (Lingard, 2013). For instance, influencing factors such as "unfair" safety policies (Dutta, 2017), language barriers (Kim et al., 2020), and lack of safety training (Hussain et al., 2020) can elevate the risk of incidents for migrant workers on the construction sites. The existing literature remains deficient concerning the factors influencing the health and safety of CMCWs (Liu and Lu, 2015). Further comprehensive investigation is warranted to elucidate the intrinsic relationship between safety influencing factors and the risks of safety outcomes among this demographic. The research findings presented in Chapter 2 demonstrate the presence of diverse factors influencing the health and safety of CMCWs. This chapter identifies the primary factors among the known influencing factors for subsequent modelling analysis. The screening criteria are determined by the frequency of each influencing factor mentioned in Table 2.3. The independent variables considered in this chapter are derived from the five influencing factors with the highest frequency literature among all the factors that impact the health and safety of CMCWs. The influencing factors and corresponding frequencies are shown in Table 4.1.

Table 4.1. The top five health and safety influencing factors

Influencing Factors	**Frequency** # Of paper (out of 60 identified articles), %
Language Barriers	55%
Inferior quality of safety training	35%
Factors related to safety policies	31.7% (6.7% + 6.7% +18.3%)
Personal Factors (Lack of safety awareness)	18.3%
Cultural differences	15%

According to Table 4.1, the five most critical influencing factors affecting the health and safety of CMCWs are safety policy, safety training, communication barriers, cultural differences, and personal variables. This study explores the interrelationship between these five influencing factors and safety outcomes of CMCWs. The explanation of each variable is presented below.

4.1.1. Safety policy (A)

Safety policy refers to organisations implementing guidelines, principles, and rules to ensure the health and safety of construction workers, visitors, and the general public during construction activities (Sitesafe, 2016). A comprehensive safety policy has clear reasonable safety protection measures and processes (Sitesafe, 2022), and must follow national health and safety regulations. For instance, in NZ, all safety policies in the construction industry are guided by the New Zealand Health and Safety at Work Act (HSW Act) (HSWA, 2015). This Act is designed to protect all construction workers, including migrant workers, in the NZCI.

4.1.2. Safety training (B)

Safety training is considered one of the primary determinants influencing the health and safety of migrant construction workers (Peiró et al., 2020, Gan and Koh, 2021, Hussain et al., 2020). Complete and effective safety training can increase the safety awareness of migrant workers and standardize their safety behaviour (Mango, 2022). The type, duration, and involvement of safety training will significantly affect the injury or death rates of migrant construction workers (Hussain et al., 2020, Oswald et al., 2019, Peiró et al., 2020).

4.1.3. Communication barriers (C)

Cultural factors including language barriers and cultural differences can influence the health and safety of migrant workers by hindering them from communicating effectively with workers or supervisors who use a different language (Bust et al., 2008, Hare et al., 2013, Icten, 2010). Communication barriers

with misunderstandings can not only reduce the efficiency of productivity but also disrupt emergency response in on-site incidents (Wasilkiewicz et al., 2016).

4.1.4. Cultural differences (D)

In addition to communication barriers, cultural differences can also affect the health outcomes among migrants, indigenous communities and ethnic minorities (Ward et al., 2011). The definition of cultural difference is the diverse attitudes, behaviours, languages, customs, and expressions unique to members of a particular ethnicity, race, or national background (Mighty Recruiter, 2022). Many supervisors or managers have a poor understanding and responsiveness to cultural diversity, which can exacerbate communication barriers between team members, particularly in multinational or multi-ethnic construction teams (Oswald et al., 2019, Ward et al., 2011, Wasilkiewicz et al., 2016).

4.1.5. Personal variables (E)

Personal variables are the summarization of personal-level influencing factors in Table 2.3. Personal variables in previous studies have been seen as direct factors related to the safety outcomes of migrant construction workers (Kim et al., 2020, Lin et al., 2018). According to the search results in Chapter 2, there are various types of personal factors related to the health and safety of migrant workers in the construction industry, and the different types of personal factors have a complex interaction. Personal variables can include low safety awareness, poor risk assessment skills, psycho-social health issues caused by discrimination or prejudice and so forth (Chávez and Altman, 2017, Fernández-Esquer et al., 2020, Meardi et al., 2012, Oswald et al., 2018). The focus of this chapter is on CMCWs in NZCI. Despite the limited literature on the safety outcomes of CMCWs concerning individual variables, this chapter will conduct data verification on this group within the NZCI, building upon the research conclusions presented in Chapter 2. Hence, this study adopts a unified variable name (personal variables) for all types of personal factors related to the characteristics of the Chinese migrant workers themselves in order to facilitate the examination of the relationship with safety outcomes.

4.1.6. Safety Outcome (O)

Safety outcomes are a measure of near misses, injuries and fatalities (Christian M.S. et al., 2009). While traditional safety research uses statistical incident and injury data to measure safety outcomes, current studies routinely use self-reported injury data collected through questionnaires (Hon et al., 2014, Huang et al., 2006, Siu O.I. et al., 2004).

4.2. Model hypotheses

Based on the results of systematic literature review presented in Chapter 2, there is a correlation between safety outcomes and influencing factors like safety policy, safety training, communication barriers, cultural differences, and personal variables (Ibarra-Mejía et al., 2021, Kwon et al., 2021, Lyu et al., 2020, Rotimi et al., 2021). Therefore, the following hypotheses are proposed:

- Hypothesis 1. (H_1): *Safety policy (A) has a significant effect on safety outcomes (O) of CMCWs.*
- Hypothesis 2. (H_2): *Safety training (B) has a significant effect on safety outcomes (O) of CMCWs.*
- Hypothesis 3. (H_3): *Communication barriers (C) have a significant effect on safety outcomes (O) of CMCWs.*
- Hypothesis 4. (H_4): *Cultural differences (D) have a significant effect on safety outcomes (O) of CMCWs.*
- Hypothesis 5. (H_5): *Personal variables (E) have a significant effect on safety outcomes (O) of CMCWs.*

4.3. Methods

This study used a quantitative approach through a questionnaire survey to collect data, and the results were analysed by a versatile statistical technique named partial least squares structure equational modelling (PLS-SEM).

4.3.1. Data collection method

The data collection method in this study was an anonymous questionnaire survey. Data collection was divided into three phases: questionnaire development, questionnaire distribution, and data review analysis phase.

4.3.1.1. Questionnaire development phase

In the questionnaire development phase, it was necessary to collect the data about the demographic information of respondents and their opinions on the relationship between the five influencing factors and safety outcomes. All items in the questionnaire related to the research objectives and each question was informed by literature review to ensure validity and reliability of the questionnaire instrument. The demographic questions included respondents' age, gender, type of passport, length of time in NZ, and length of work in a construction company. Risk-factor questions included the exploration of five influencing factors and safety outcomes, which were called constructs A, B, C, D, E and O respectively. The constructs and references are shown in Table 4.2.

Table 4.2. Construct measurement of analysis

Construct	Item Number	Supporting Literature
Safety policy (A)	3	(Kwon et al., 2021, Lyu et al., 2018, Rotimi et al., 2021, Wu et al., 2015)
Safety training (B)	3	(Hussain et al., 2020, Ibarra-Mejía et al., 2021, Vignoli et al., 2021)
Communication barriers (C)	3	(Ibarra-Mejía et al., 2021, Lyu et al., 2020, Pink et al., 2010)
Cultural differences (D)	3	(Oswald et al., 2019, Rotimi et al., 2021)
Personal variables (E)	6	(Bust et al., 2008, Ibarra-Mejía et al., 2021, Lyu et al., 2018, Welton et al., 2018, Wu et al., 2015)

Safety outcomes (O)	3	(Lyu et al., 2018, Ghodrati et al., 2018, Newaz et al., 2023)

The final version of the questionnaire survey is shown in the Appendix 2-1 to 2-4. According to Table 4.2, each construct was quantified through multiple measurement items. Therefore, there were a total of 21 risk-factor questions and all of these were multiple-choice. The chosen answer for these multiple-choice questions was presented by a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). In addition, since the interviewees were all Chinese migrant workers, both English and Chinese versions of the questionnaire were utilised to avoid misunderstandings about the questions in questionnaire surveys caused by potential language barriers. The research group used the English version of the questionnaire as a framework for reviews and revisions, and translated the final version into Chinese. The translation was handled by the PhD student within the research group and peer-reviewed by associate professors in PRC for validation. Moreover, our research group also submitted ethic application for the questionnaire survey during this phase. The project has been evaluated by peer review and judged to be low risk (with Ethics Notification Number: 400026149). Respondents who met the criteria and expressed a willingness to participate in this study were required to sign this consent form, which is shown in Appendix 2.

4.3.1.2. Questionnaire distribution phase

The next phase is the questionnaire distribution phase. The questionnaire survey was distributed in two ways: online questionnaire survey and offline questionnaire survey. Respondents could participate in this questionnaire survey after receiving the link or QR code of the online questionnaire via email, WhatsApp, WeChat, or LinkedIn. Construction companies and stakeholders, such as Site Safe NZ, Master Builder Association, and New Zealand Chinese Building Industry Association (NZCBIA), promoted the research through their networks. A paper-based questionnaire was also distributed to increase the number of respondents. The specific approach was to visit Chinese migrant workers who

were willing to participate in the survey in a construction site in Auckland, NZ through distribution of the printed paper questionnaire.

4.3.1.3. Questionnaire data review phases

During the questionnaire data review phase, the applicability of the collected questionnaires is assessed. All incomplete questionnaires should be discarded. The research subjects in this study are Chinese migrant workers in the construction industry. This study also excluded the questionnaires where the respondents did not meet the definition used of this study.

4.3.2. Data analysis method

The primary method of data analysis was Partial Least Squares Structural Equation Modelling (PLS-SEM), which is a subset of Structural Equation Modelling (SEM). SEM is a multivariate technique that integrates various aspects of factor analysis and regression (Hair Jr et al., 2021a, Hair Jr et al., 2021b). In comparison to first-generation multivariate data analysis techniques like cluster analysis, analysis of variance and multiple regression, SEM exhibits advanced statistical analysis techniques for the social sciences (Hair Jr et al., 2021a). SEM can simplify not only intricate structural models but also explain multiple statistical relationships through visualization and model validation (Dash and Paul, 2021). In essence, SEM has the characteristic of both factor and multiple regression analyses (Dash and Paul, 2021). SEM is beneficial in clarifying the interrelationship between latent constructs (or latent factors) by various measures (Hooper et al., 2008) and is a popular tool due to its flexibility and generality (Mueller and Hancock, 2018).

The application of SEM in research analysis has gradually increased due to its high efficiency in evaluating the reliability and validity of measures involving multiple constructs, as well as its ability to test relationships within structural models (Hair Jr et al., 2017). Researchers can effectively validate the intricate theoretical models by utilising empirical data through the process of SEM (Dash and Paul,

2021). Therefore, in this study, this second-generation technique, SEM, was used to analyse the data collected through questionnaire surveys.

SEM can be divided into two main approaches: covariance-based SEM (CB-SEM) and partial least squares structure equational modelling (PLS-SEM) (Hair Jr et al., 2021b). There are several differences between CB-SEM and PLS-SEM. The core distinction between these two approaches stems from the utilisation of different types of models; CB-SEM is based on the common factor model and PLS-SEM is based on the composite model (Hair Jr et al., 2017). In addition, the philosophical distinction of these two SEM methods is significantly different (Dash and Paul, 2021). The objective of CB-SEM is to test and confirm a research theory, whereas the objective of PLS-SEM focuses more on theory development (Dash and Paul, 2021). Moreover, a disparity exists in the statistical objectives of CB-SEM and PLS-SEM.

The statistical objective of CB-SEM is to identify the optimal model fit by tuning its parameters to minimize the differences between the observed data and the model's estimated covariance matrix (Hair Jr et al., 2017). In contrast, the statistical objective of PLS-SEM is to enhance the explanation of variance within the dependent variable(s) to the maximum extent possible (Hair Jr et al., 2017). One of the key characteristics of PLS-SEM is that this approach can allow the seamless incorporation of reflections and the formative measurement models that clearly show researchers the relationship between constructs and indicators.

The objective of this stage is to explore the interrelationship between the five identified influencing factors and the safety outcome, as well as to predict the influence of each influencing factor on the dependent variables in the theoretical model. It is an exploratory study rather than a confirmatory one. Furthermore, there is an additional justification for selecting PLS-SEM instead of CB-SEM. The

association between the variables in PLS-SEM does not have to follow the normal distribution (Hair Jr et al., 2017), while CB-SEM operates under the assumption of a normal distribution for the data (Sarstedt et al., 2023).

4.3.3. The PLS-SEM Algorithm

The first step of PLS-SEM analysis is to establish a preliminary path model, which is shown in Figure 4.1.

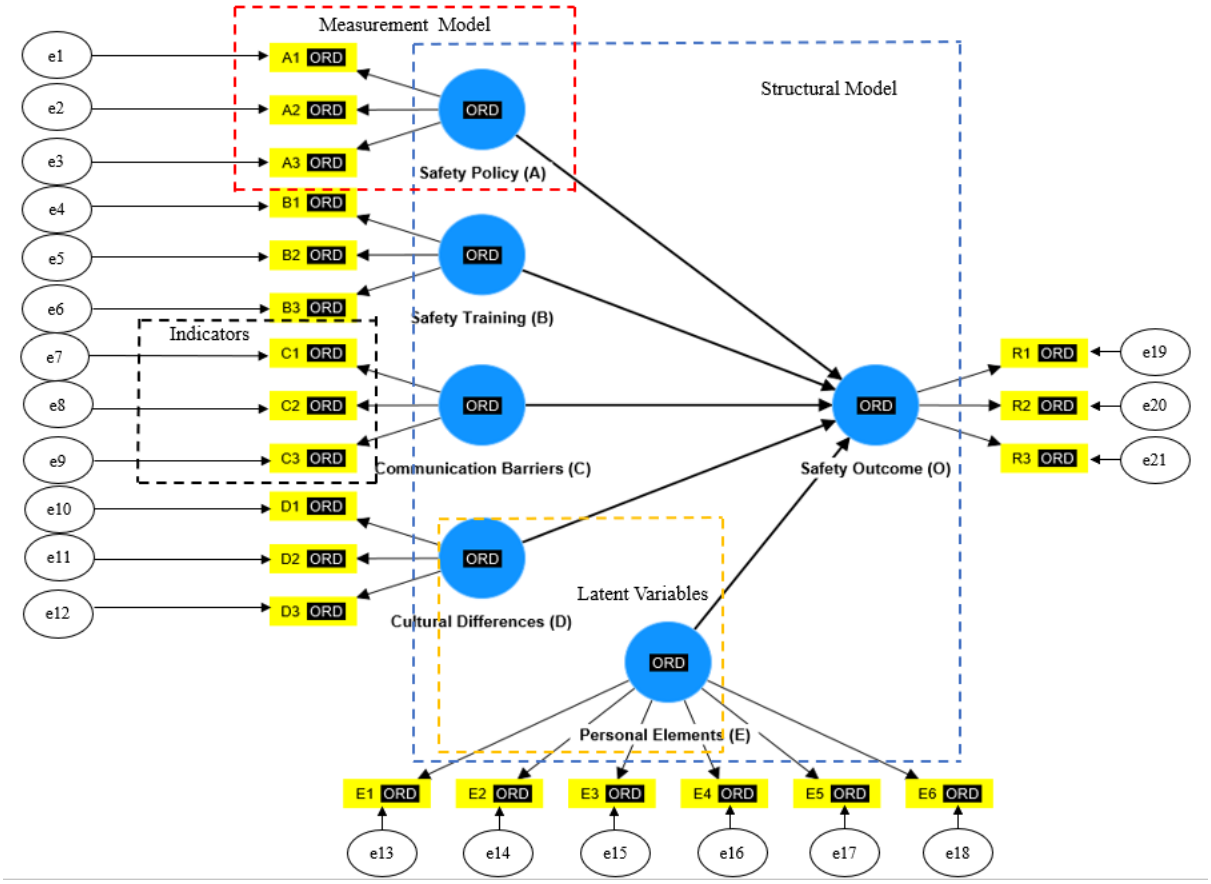

Figure 4.1. Introduction of PLS-SEM (*Source: Authors*)

The path model illustrates the hypotheses and variable relationships that were examined in the application of PLS-SEM. The path model includes the following components:

1) Constructs (latent variables),

2) Indicators (items or manifest variables),

3) Measurement model (outer model), and

4) Structural model (inner model).

The constructs (latent variables) are represented as circles (A, B, C, D, E, O) in path models. Latent variables (constructs) refer to variables that cannot be measured directly (Hair Jr et al., 2021b). For instance, it is difficult to use specific numerical values to describe the safety policy or cultural differences. Indicators (items or manifest variables) are represented as rectangles in the path model (Hyman and Leibowitz, 2001); thus, according to Figure 4.1, items like A1, A2, A3, B1…, R1, R2, R3 belong to indicators. The data of all the indicators are ordinal data (ORD) in this survey. These indicators can be directly measured through raw data. It is worth noting that within the model, the path is linked by connecting arrows, which indicates the inter-relationship between both constructs and between constructs and indicators. Arrows consistently maintain a unidirectional flow, which effectively illustrates the causal connections between constructs and indicators or between dependent variables and independent variables.

The statistical model underlying PLS-SEM includes two elements to ensure efficient calculation and operation of data analysis. One is measurement model, also called outer model, and the other is structural model (inner model). These two models are shown in Figure 4.1. The measurement model consists of the latent variables (constructs) and the observed variables (indicators). The measurement model represents the relationships between each latent variable (construct) and the associated observed variables (indicators). If the arrows point from the indicator to the latent constructs, it means the constructs are measured with formative indicators (Sarstedt et al., 2016). Conversely, if the arrow is directed from the latent constructs to the indicator, it represents that the latent constructs are measured by the effect of the indicator reflection (Sarstedt et al., 2016).

In this study, all the measurement models are reflective measurement models. For instance, the construct 'Safety Policy' in Figure 4.1 is 'calculated' based on the weighted sum of the 3 observed variables (A1, A2, and A3). In the reflective measurement model, the error terms are usually used to stand for the unexplained variance when path models are estimated. In Figure 4.1, the error terms (e1, e2, e3…, e21) are connected to the reflectively measured indicators. The structural model can effectively reveal the relationship between independent latent variables and dependent latent variables. The relationships among the latent variables are measured based on model specification. PLS at this stage needs to perform simple and/or multiple regression iterations based on the established path model until the answer converges to a set of weights for predicting the latent variables scores (Aibinu and Al-Lawati, 2010).

4.3.4. The Process of PLS-SEM

The following five steps are involved in the process of performing PLS-SEM. Step 1 is to adequately identify the individual constructs. This means that all the constructs should be proposed in the hypothesized model (Dash and Paul, 2021). The individual constructs are primarily defined based on structural and measurement theories (Maydeu-Olivares et al., 2018). Step 2 is preparing for Confirmatory Factor Analysis (CFA). CFA is utilized to evaluate the measurement model in the PLS-SEM (Hayes et al., 2017). The difference between CFA and Exploratory Factor Analysis (EFA) is that CFA validates existing factor specifications with empirical data (Dash and Paul, 2021). Once the constructs are defined, measurement models, structural models, and path diagrams should be drawn. The elements in this step should include indicators, loadings of the indicators, and error terms (Dash and Chakraborty, 2020). Step 3 is running CFA. This step aims to assess the reliability and validity of the measurement models. All the aggregation of the indicators under a latent variable should be more than 0.6. Moreover, the reliability of the PLS-SEM can also be assessed via Average Variance Extracted (AVE); the value of AVE should be more than 0.5 for each construct (Hair Jr et al., 2021b).

In addition, the validity evaluation of the PLS-SEM involves confirming both convergent and discriminant validity to determine the nature of measurement models. In order to establish good convergent validity and discriminant validity, all indicators under a latent variable should have high loadings of more than 0.6 (Shi and Maydeu-Olivares, 2020). The outcomes of reliability and validity evaluation can be utilized to gauge the model fit of the overall structure (Dash and Paul, 2021). There are three categories of model fit: absolute, incremental, and parsimonious. According to model fitting results and research requirements, researchers can modify the model by addressing high covariance among measurable indicators (Dash et al., 2021). The next step (Step 4) is structural modelling. Based on the theoretical relationship between the dependent latent variables and independent latent variables established in the hypothesis, PLS-SEM can effectively assess the validity of the hypothesized model and model fit. After that, researchers can use relevant statistical tools to test hypothesis and path coefficients (Mueller and Hancock, 2018). In the last step (Step 5), scholars can draw conclusions corresponding to research directions based on the results of PLS-SEM data analysis (Dash et al., 2021).

The next phase of PLS-SEM is model interpretation, which can be achieved in two stages. The first stage is to evaluate the validity and reliability of the measurement constructs according to the examination results of the individual loading of each item, internal composite reliability, and discriminant validity (Chin, 1998). In the second stage, the structural model should be examined to assess the relationships between the independent latent variables and the dependent variable. The five hypotheses in this study can be verified by comparing whether the path coefficients in the structural model are standardized betas (Compeau et al., 1999).

The third phase is using PLS bootstrapping to validate the model. In PLS, the structural model that verifies the intrinsic relationship between independent latent variables and dependent variables is very important for assessing whether the model has the possibility of accurately predicting the response of future samples (Aibinu and Al-Lawati, 2010). Model validation can be achieved by testing the significance of the t-value of the path coefficients of the structural model (Hair et al., 1998).

4.3.5. Statistical packages for PLS-SEM

While numerous statistical software packages exist for conducting Structural Equation Modelling (SEM) data analysis, the most popular data analyses statistical software packages for PLS-SEM are IBM SPSS Amos and Smart PLS (Dash and Paul, 2021, Ringle et al., 2022). The difference between these two software packages is that Smart PLS is based on partial least squares (variance/ regression) instead of covariance (Haenlein and Kaplan, 2004). This study opted for the utilization of Smart PLS 4.0 software to execute the experimental procedures. Smart PLS is a milestone in latent variable analysing modelling (Hair, 2023). This software simplifies the process for researchers to utilize intricate data and methods (Ahmad and Afthanorhan, 2014). This software can visualize both the loadings of the constructs and the relationships among the dependent variables and independent variables (Dash and Paul, 2021).

Smart PLS can not only have convenient operability but can also incorporate a range of functions to safeguard the integrity of the PLS algorithm, such as Partial least squares (PLS) path modelling algorithm (including consistent PLS), ordinary least squares regression based on sub scores, Advanced bootstrapping options, Blindfolding, and Importance-Performance Matrix Analysis (IPMA) (Pat Research, 2013). The PLS-SEM model drawn with Smart PLS 4.0. is shown in Figure 4.1.

4.4. Results

The data collection phase for the questionnaire survey in this study spanned from September 2022 to March 2023. Within this period, a total of 156 questionnaire responses were gathered from both online and offline sources. According to the data screening criteria outlined in section 4.3.1.3, a refined selection process resulted in the inclusion of 120 survey datasets for the final analysis in this experimental endeavour.

4.4.1. Demographic data

On the premise of not violating ethical issues, this study conducted statistics on the demographic information of respondents to ensure the veracity and efficacy of the collected data to conduct research concerning the health and safety conditions of Chinese migrant workers within the NZCI. The data results after excluding invalid surveys are shown in Table 4.3.

Table 4.3. Demographic profile of the sample

Demographic factor	Categories	Frequencies	Percentages
Gender	Male	94	78.3%
	Female	24	20.0%
	Prefer not to say	2	1.7%
Age	18-29	55	45.8%
	30-39	39	32.5%
	40-49	20	16.7%
	Prefer not to say	6	5.0%
Education level	Primary or below	0	0.0%
	Secondary	7	5.8%
	Certificates and diplomas	21	17.5%
	Bachelor’s degree or higher	92	76.7%
Time in New Zealand	≤5 years	48	40.0%
	6-10 years	56	46.7%
	≥11 years	16	13.3%
	≤5 years	110	91.7%

Time in construction company	6-10 years	7	5.8%
	≥11 years	3	2.5%

78.3% of surveyed respondents were male. The proportions of respondents in the different age groups are 45.8%, 32.5%, 16.7%, and 5.0%. In addition, 76.7% of respondents hold bachelor or higher degrees, and the rest hold certificates and diplomas, and secondary schooling accounting for 17.5% and 5.8% respectively. Moreover, the percentages of respondents who have been in NZ for less than 5 years, 6-10 years, and more than 10 years were 40.0%, 46.7%, and 13.3% respectively. The majority of respondents had less than or equal to 5 years of work experience, accounting for 91.7%.

4.4.2. Model adjustment

The theoretical model in this study consists of six constructs and all the measurement models are reflective models. The original theoretical model drawn by Smart PLS 4.0 is shown in Figure 4.2. Based on this original theoretical model, we inputted the data outcomes from the collected 120 questionnaires into the Smart PLS 4.0 software. Subsequently, we used the calculation software to assess the reliability of indicators through the outer loading value of each latent variable. The loading values are shown in Table 4.4.

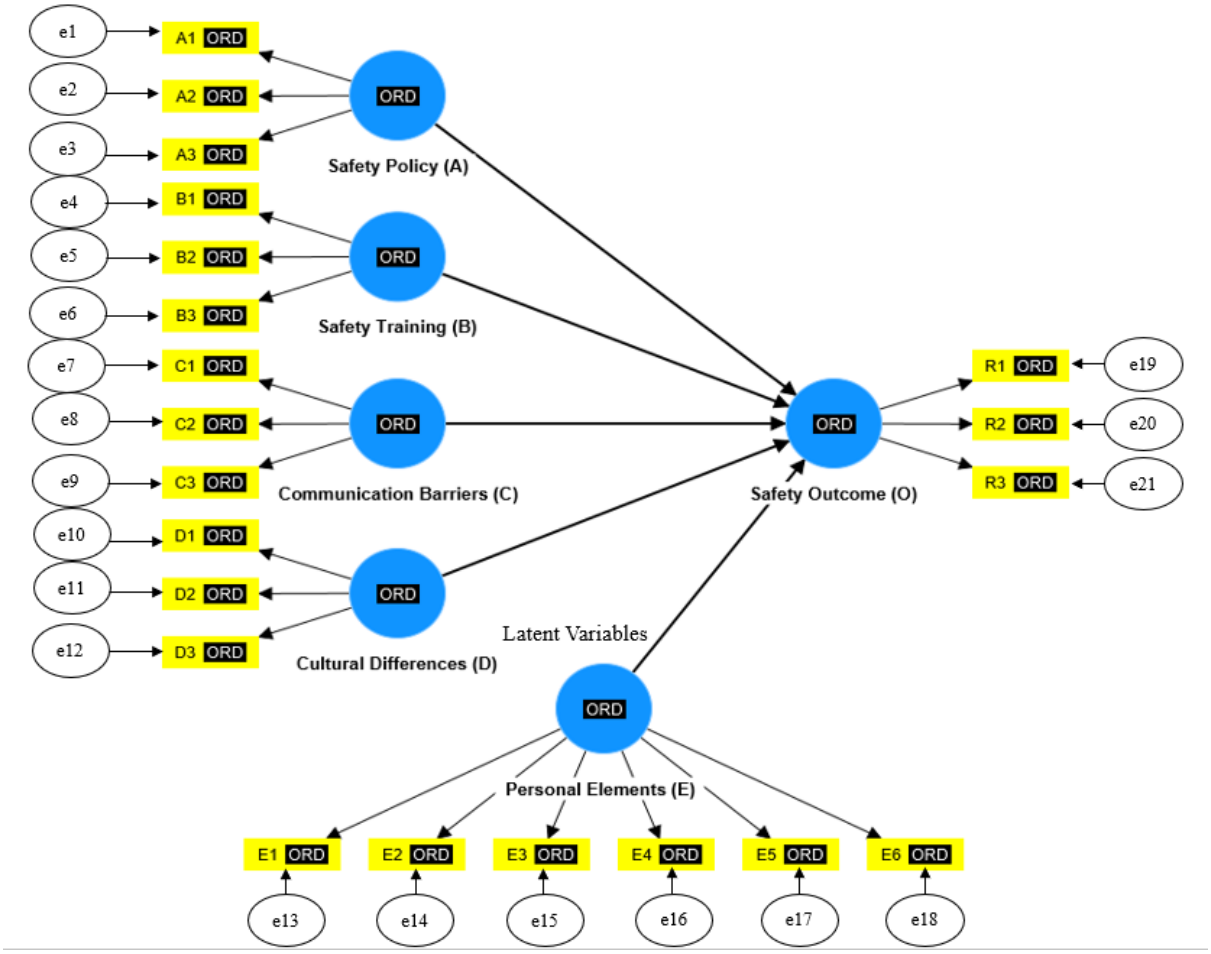

Figure 4.2. Original theoretical model in PLS-SEM

Table 4.4. Outer loadings of each latent variable

Indicator	Outer Loading Value
A1	0.093
A2	0.798
A3	0.898
B1	0.689
B2	0.292
B3	0.188
C1	0.652
C2	0.804
C3	0.738

D1	0.478
D2	0.622
D3	0.906
E1	0.220
E2	0.363
E3	0.792
E4	0.616
E5	0.538
E6	0.366
R1	0.486
R2	0.896
R3	0.823

In PLS-SEM, the outer loading values of each indicator should be over 0.7 (Lohmöller, 1989, Hussain et al., 2018). It is evident that many indicators in the original model do not meet this requirement from Table 4.4. However, in the multi-indicator PLS-SEM model, indicators that do not meet the requirements should not be simply removed outright. Instead, they should be assessed using multiple criteria of the PLS-SEM model, such as the AVE value and Composite Reliability (Research With Fawad, 2022).

There is a correlation between the indicators in the same latent variable. This means that when an indicator is removed, other indicator loadings will increase in the same measurement models (Hair Jr et al., 2021b). The theoretical model should be revised to ensure the reliability of the PLS-SEM (Durdyev et al., 2018). Therefore, this study made several adjustments to the theoretical model to ensure that all data fulfilled the reliability requirements. The adjusted model with indicator loadings, path coefficients (β) and R^2 value is shown in Figure 4.3.

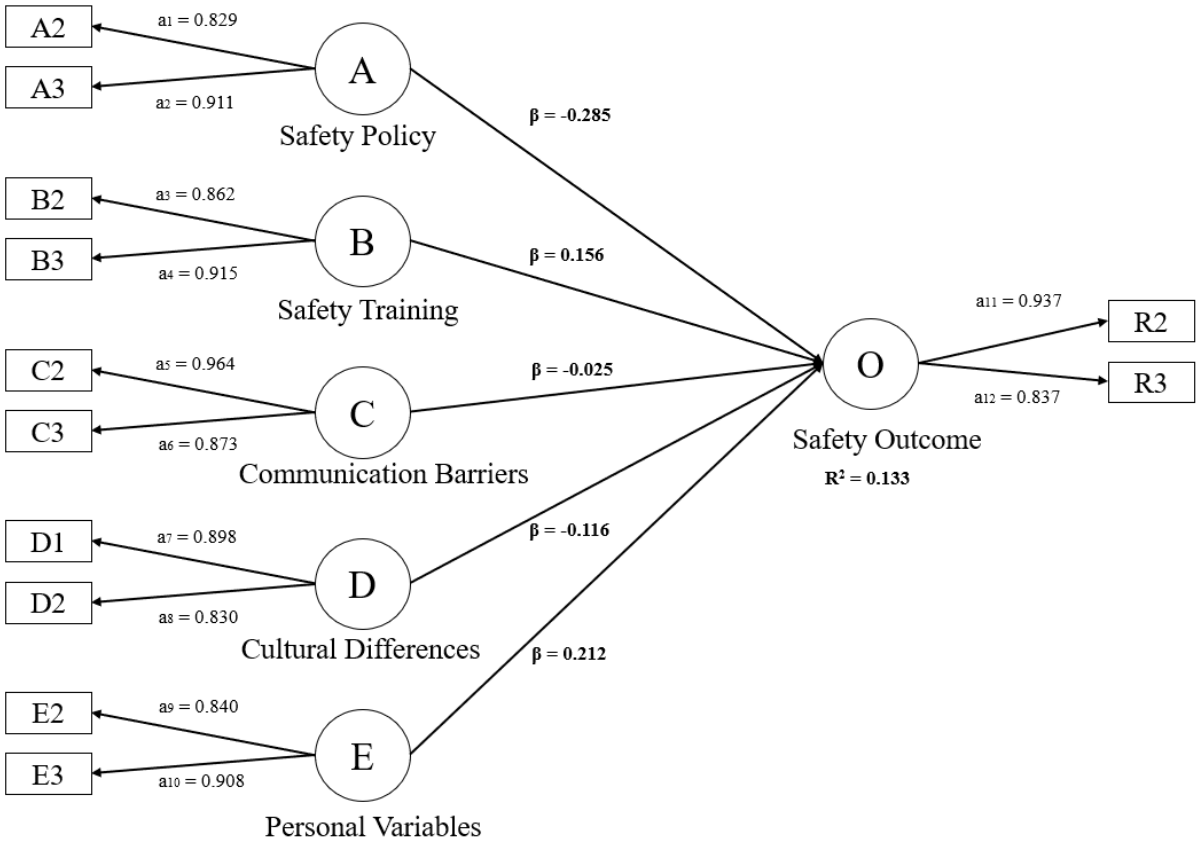

Figure 4.3. Final theoretical model for PLS-SEM data analysis (*Source: Authors*)

Figure 4.3 showed the final theoretical model of this study, and all the 12 indicator loadings were fit for the reliability and validity measures. Based on the final theoretical model, each indicator and its corresponding question in the questionnaire survey is detailed in Table 4.5. The indicator loadings and path coefficients (β) in PLS-SEM are listed in Table 4.6. The subsequent section (Section 4.4.3) will comprehensively illustrate the path coefficient and R-square value.

Table 4.5. Final indicator and its corresponding question in the questionnaire survey (*Source: Authors*)

Independent Latent Variables	Item Code	Questions	Answer's Options
Safety Policy	A2	I think the health and safety policy is effectively followed in my company.	

	A3	My company has a set of well-established safety policies such as a written policy on safety, a safety committee, and regularly scheduled safety meetings.	1 (strongly disagree) to 5 (strongly agree).
Safety Training	B2	I can apply the knowledge of safety training to practical work.	
	B3	Safety training is helpful to my work in improving health and safety awareness and work skills.	
Communication Barriers	C2	I can communicate personal or work-related issues with my co-workers or supervisors effectively and frequently.	
	C3	I can communicate with others at the workplace and can effectively understand others' requirements.	
Cultural Differences	D1	I can integrate well with other workers in spite of cultural differences.	
	D2	Some common behaviors in my hometown are regarded as unsafe behaviors in NZ.	
Personal Variables	E2	Sometimes I must take risks to finish the job.	
	E3	I am easier to expose to near-miss incidents due to work stress and negative emotions (like loneliness and homesickness).	
Safety Outcomes	R2	How often have you faced a work-related near miss incident?	1 (never) to 5 (always).
	R3	How often have you been injured or sick at work while carrying out your work activities?	

Table 4.6. Details of independent latent variables and associated questionnaire items (*Source: Authors*)

	Loadings of Variables	Path in Structural Model	Path Coefficients (β)

A2	0.829	A to O	-0.285
A3	0.911		
B2	0.862	B to O	0.156
B3	0.915		
C2	0.964	C to O	-0.025
C3	0.873		
D1	0.898	D to O	-0.116
D2	0.830		
E2	0.840	E to O	0.212
E3	0.908		
R2	0.937	None	
R3	0.837		

According to Table 4.6, all indicator loading values meet the criteria of PLS-SEM (greater than 0.7) after making adjustments to the measurement models. The values displayed on the arrows within the structural model are path coefficients (beta weights) that indicate the effects of independent variables on dependent variables (Williams and Williams, 2005). Path coefficient plays a vital role in hypothesis testing in PLS-SEM experiments (Kock, 2014). The path coefficient can not only reflect the degree of influence of the independent variable on the dependent variable but also explain the conceptual model (Dash and Paul, 2021). The values of path coefficients were obtained from regression analyses on the independent and dependent variables in the path model (Wright, 1960). Each path coefficient aligns with a hypothesis, allowing the opportunity to evaluate each hypothesis through the associated P value linked to the path coefficient (Kock, 2014).

The difference in the sign of path coefficients (positive coefficients and negative coefficients) reflects a change in the interactions between independent variables and dependent variables in the structural model (Mclntosh and Gonzalez-Lima, 1994). For instance, a positive coefficient signifies that

increasing the unit value of one construct can result in a proportional rise in the value of the other construct. Conversely, a negative coefficient indicates that when the unit value of the preceding construct increases, the value of the corresponding construct decreases. Moreover, a difference in the absolute magnitude of the path coefficients indicates a change in the strength of the influence between independent variables and dependent variables (Massachusetts Institute of Technology, 2013). The significance level of the path coefficient is to test the reliability and validity of the structural model of PLS-SEM. This part will be illustrated in detail in Section 4.4.4.

4.4.3. Assessing measurement model

Assessing the measurement model is the second step in running statistical software packages of Smart PLS (Aburumman et al., 2022). The measurement model reflects how the observed indicators influence the latent variables. Hence, through the measurement model assessment, researchers can establish whether the observed indicators can effectively gauge whether the latent variables align with the research purposes (Aburumman et al., 2022). This process can contribute to the validity and reliability of the theoretical model. There are three aspects to assessing the measurement model, internal consistency reliability, convergent validity, and discriminant validity (Aibinu and Al-Lawati, 2010). These three quantitative measures are necessary to evaluate the reflective measurement model (Hair Jr et al., 2017).

4.4.3.1. Internal consistency reliability

The role of internal consistency reliability is to measure the degree of internal association between indicators of the same construct in the measurement model (Hair Jr et al., 2021b). The internal consistency reliability test is mainly carried out by Cronbach's alpha (CA) and composite reliability (CR) methods (Hair Jr et al., 2017). CA focuses on assessing the reliability of the measurement model itself (the degree to which indicators are related to each other), while CR looks at the reliability of the measurement related to the underlying concept (the degree to which the items collectively represent

the concept) (Aburumman et al., 2022). The accepted values for CA should be between 0.70 and 0.95 (Aburumman et al., 2022). Some researchers have recommended the composite reliability rhoc proposed by Jöreskog (1971) as the primary measure in PLS-SEM because this measure considers the indicators' differential weights (Dijkstra and Henseler, 2015). Reliability values are considered "acceptable for exploratory research" when the value of composite reliability rhoc is between 0.60 and 0.70, whereas values between 0.70 and 0.90 range are regarded as "satisfactory to good" (Jöreskog, 1971). However, once the reliability values exceed 0.90 (and definitely above 0.95), the internal consistency reliability of the measurement model is considered problematic since this suggests the presence of redundant indicators, which can reduce the effectiveness of the measurement model (Jöreskog, 1971). Table 4.7 shows the CA and CR values for each measurement model in this study. It can be seen that all the CA and CR values are within the acceptable range.

Table 4.7. CA and CR values of internal consistency reliability (*Source: Authors*)

Latent Variable	Cronbach's alpha	Composite reliability (rhoc)
Communication Barriers (C)	0.832	0.876
Cultural Differences (D)	0.667	0.856
Personal variables (E)	0.697	0.866
Safety Outcome (O)	0.745	0.882
Safety Policy (A)	0.688	0.862
Safety Training (B)	0.736	0.882

4.4.3.2. Convergent validity

In addition to the individual consistency reliability analysis, convergent validity is also an important indicator of internal consistency. Convergent validity refers to the degree to which the construct converges to describe the variance of the indicators in the measurement model (Hair Jr et al., 2017). Convergence can indicate that the same or similar constructs should exhibit high correlation (Aburumman et al., 2022). In PLS-SEM, the convergent validity of the measured constructs can be determined by Cronbach's alpha/composite reliability scores (ρc), and AVE (Hair Jr et al., 2021b). As previously stated, Cronbach's alpha is the coefficient of reliability (or consistency) used to evaluate the effect of a set of variables measuring a single one-dimensional latent structure (Cronbach, 1951). The acceptable values of CA and CR are, respectively, more than 0.6 and 0.7 (Aibinu and Al-Lawati, 2010).

According to Table 4.7, all the measurement models meet the numerical specification criteria of Cronbach's alpha. Therefore, this study further tested the convergent validity of the measurement model by measuring the AVE value. The AVE is used to evaluate the convergent validity of the latent variables (Durdyev et al., 2018). The definition of AVE is the grand average of the squared loadings of the indicators in the measurement model. The AVE is calculated by the sum of the squared loadings by the number of indicators (Hair Jr et al., 2021b). The AVE values of the latent variables should be higher than 0.5 (Fornell and Larcker, 1981), and all the AVE value in this study (shown in Table 4.8) satisfy this standard.

Thus, the results illustrate that the measurement model has strong internal consistency and convergent validity.

Table 4.8. Reliability analysis of variables (*Source: Authors*)

Latent Variable	Average variance extracted (AVE)

Communication Barriers (C)	0.846
Cultural Differences (D)	0.748
Personal variables (E)	0.765
Safety Outcome (O)	0.790
Safety Policy (A)	0.758
Safety Training (B)	0.789

4.4.3.3. Discriminant validity

Discriminant validity refers to the degree of empirical discrimination between a latent variable (construct) and others in the structural model (Hair Jr et al., 2021b). The assessment of discriminant validity can facilitate the identification of a group of constructs and indicators that exhibit the strongest interrelationship across various measurement models (Aburumman et al., 2022). Fornell and Larcker, (1981) proposed the conventional method for assessing discriminant validity; the method evaluated discriminant validity by comparing the AVE (shared variance within) for each construct with the shared variance between all model constructs. However, existing research have indicated that the Fornell–Larcker criterion showed a poor performance in identifying discriminant validity problems (Radomir and Moisescu, 2020). Hair Jr et al., (2017) state that the Fornell-Larcker criterion still remains the most common method for assessing discriminant validity in the context of PLS-SEM, but numerous researchers have begun to use the heterotrait-monotrait ratio of correlations (HTMT) criterion as a more precise measure of discriminant validity in PLS-SEM (Voorhees et al., 2016). HTMT criterion have high sensitivity rates which are beneficial for effectively identifying a lack of discriminant validity (Henseler et al., 2015). According to (Henseler et al., 2015), the accepted values

for a HTMT criterion should less than 0.85. Based on the calculation results of Smart PLS 4.0, Table 4.9 presents the results for the HTMT values for each construct. It can be seen that, in this study, the discriminant validity values for all constructs ranging between 0.052 and 0.416 for discriminative validity based on the HTMT criterion.

Table 4.9. HTMT for discriminant validity

	Safety Policy (A)	Safety Training (B)	Communication Barriers (C)	Cultural Differences (D)	Personal Variables (E)	Safety Outcome (O)
Safety Policy (A)						
Safety Training (B)	0.416					
Communication Barriers (C)	0.182	0.166				
Cultural Differences (D)	0.198	0.245	0.182			
Personal Variables (E)	0.267	0.153	0.052	0.334		
Safety Outcome (O)	0.320	0.094	0.055	0.076	0.274	

Analysis of cross-loadings can be another method to assess the discriminant validity (Aibinu and Al-Lawati, 2010). In this study, SmartPLS 4.0 was utilised to conduct cross-loading analysis as well as to

derive the latent variable scores for all variables and standardized scores for each measurement item. The results of cross loading factor analysis of variables associated indicators are shown in Table 4.10. It can be found that each latent variable has the highest value for its own load when compared to other latent variables. This means that each item has strong discriminant validity (Hair Jr et al., 2021b).

Table 4.10. Cross loading factor analysis of variables of each indicator (*Source: Authors*)

	Safety Policy (A)	Safety Training (B)	Communication Barriers (C)	Cultural Differences (D)	Personal variables (E)	Safety Outcome (O)
A2	0.829	0.268	0.126	-0.125	-0.034	-0.184
A3	0.911	0.234	0.079	-0.092	-0.14	-0.249
B2	0.323	0.862	0.118	-0.147	-0.126	0.054
B3	0.196	0.915	0.125	-0.151	-0.063	0.068
C2	0.06	0.144	0.964	0.145	0.016	-0.056
C3	0.188	0.098	0.873	0.118	-0.002	-0.03
D1	-0.054	-0.116	0.171	0.898	0.279	-0.055
D2	-0.17	-0.183	0.07	0.83	0.137	-0.044
E2	-0.277	-0.106	-0.012	0.119	0.84	0.149
E3	0.046	-0.077	0.026	0.296	0.908	0.193
R2	-0.288	0.062	-0.058	-0.075	0.174	0.937
R3	-0.131	0.063	-0.025	-0.016	0.184	0.837

In summary, these results show that the measurement model has good individual reliability, convergent validity, and discriminant validity. This illustrates that the relationship between latent variables and the dependent variable in the model has satisfactory robustness.

4.4.4. Assessing the structural model

The next step for PLS-SEM is to assess the structural model. The structural model can also be called the inner model, and the assessment of the structural model seeks to evaluate both the predictive capabilities of the model and the relationships between various constructs (Hair Jr et al., 2021b). Firstly, the collinearity examination is a crucial test to ensure that the regression results do not deviate. The collinearity is determined by the variance inflation factor (VIF) value and the ideal VIF value should be less than 3 (Hair et al., 2019). The VIF values in this study are shown in Table 4.11 and all are acceptable.

Table 4.11. VIF value of inner model (*Source: Authors*)

Variables	VIF
A2	1.379
A3	1.379
B2	1.514
B3	1.514
C2	2.028
C3	2.028
D1	1.334
D2	1.334
E2	1.4
E3	1.4
R2	1.544

R3	1.544

Secondly, there are four aspects that need to be examined in order to assess the structure model; namely, coefficient of determination (R^2), cross-validated redundancy (Q^2), effect sizes (f^2), and path coefficients (hypotheses testing) (Hair Jr et al., 2021b). R^2 value is the measure of the explanatory power of the PLS-SEM model (Shmueli and Koppius, 2011). Hair et al. (2011) divided the explanatory power of the PLS-SEM model into substantial, moderate and weak levels with R^2 values of 0.75, 0.50, and 0.25, respectively. The R^2 value in this study is 0.133 representing a weak explanatory power. This demonstrates that only 13.3% of the changes in safety outcome are due to the five latent variables in this model.

The third step is to examine the validation of the structural model. Each path of the structural model in PLS-SEM corresponds to one hypothesis. The larger the path coefficient, the stronger the substantial effect on the endogenous latent constructs (Hussain et al., 2018). The value of the path coefficient was achieved using the bootstrap function of the PLS-Graph 3.0 with 500 resamples, and the result of each path coefficient, t-value, and p-value is shown in Table 4.12. Whether the hypothesis is significant depends on the p-value (Biau et al., 2010). When the p-value is greater than 0.10, less than 0.05, or less than 0.01, the assumptions are "not significant", "significant" and "highly significant" respectively (Thiese et al., 2016).

Table 4.12. The assessment of structural model (*Source: Authors*)

Path	Path Coefficients (β)	T statistics (|O/STDEV|)	P values
Communication Barriers (C) to Safety Outcome (O)	-0.025	0.225	0.822

Cultural Differences (D) to Safety Outcome (O)	-0.116	0.996	0.319
Personal variables (E) to Safety Outcome (O)	0.212	2.035	0.042
Safety Policy (A) to Safety Outcome (O)	-0.285	2.812	0.005
Safety Training (B) to Safety Outcome (O)	0.156	1.436	0.151

The results of estimation of path coefficients and T-statistics demonstrates that:

(1) Safety policies and personal variables have a significant influence on safety outcomes,

(2) Safety training, communication barriers, and cultural differences had an insignificant association with safety outcomes in this sample of workers.

It can be seen from Table 4.12 that only two paths (from Personal variables (E) to Safety Outcome (O) and from Safety Policy (A) to Safety Outcome (O)) show significance, and safety policy was the most significant impactor. Based on the path coefficient of each independent variable, safety policies (β= -0.285), communication barriers (β= -0.025), and cultural differences (β= -0.116) had a negative impact on safety outcomes, but safety training (β=0.156) and personal variables (β= 0.212) had a positive influence. It is worth noting that a negative path loading is the same as a negative regression coefficient, which means that the statistical significance could not be affected by the positive or negative regression coefficient (Hair Jr et al., 2021b). Safety policies and personal variables had a significant impact on safety outcomes. Among the five independent variables, safety policy had the largest path coefficient, which means it had the strongest relationship with safety outcome. Therefore, construction companies should pay more attention to safety policies to decrease the injury and fatalities of Chinese migrant workers in the NZCI.

4.5. Discussion

This study explores the relationship between the health and safety factors and safety outcomes for Chinese migrant workers in the NZCI. According to the systematic literature review in Chapter 2, we discovered that safety policies (Welton et al., 2020), safety training (Ibarra-Mejía et al., 2021), communication barriers (Kim et al., 2020), cultural differences (Al-Bayati et al., 2018), and personal variables (Oswald et al., 2019) are the main factors influencing the health and safety of migrant construction workers. Therefore, this Chapter further examines the inter-relationships between these factors and safety outcomes based on the PLS-SEM methodology.

The path coefficient and p-value in Table 4.12 provide a comprehensive reflection of how these five safety factors impact safety outcomes. Based on the questionnaire responses to questions corresponding to each construct in Table 4.5 and the 5-point Likert scale, this research can deduce the positive or inverse relationships between various independent variables and dependent variables. For instance, the path coefficient between Safety Policy (A) and Safety Outcome (O) is -0.285 (β value). This indicates that these two constructs have a negative relationship; that is, the higher score earned in the indicators of construct A (A2 and A3), the lower score shown in the indicators of construct O (R2 and R3). According to the questions corresponding to A2 and A3, the higher the Likert value entered by respondents, the greater their comprehension of the safety policy. However, for questions R2 and R3, the higher the value respondents assigned, the greater their vulnerability to safety incidents or risks. Therefore, the negative relationship between construct A and O means that Chinese migrant workers with higher safety policy knowledge can experience a lower risk of safety incidents. The research results indicate that another significant health and safety influencing factor is the personal variable (E). The path coefficient between the Personal Variable (E) and Safety Outcome (O) is 0.212 (β value), which shows a positive relationship between the independent variable and the dependent variable. Based on the responses to questions concerning E2 and E3, the majority of respondents acknowledged

that they have to take risks to meet job deadlines and expressed concerns about potential injuries due to work-related stress. Hence, this result not only highlights that the unsafe behaviours of CMCWs can endanger their health and safety, but it also verifies the accuracy of the theoretical model.

The key findings suggest that safety policy and personal variables are the main factors influencing the safety outcomes of CMCWs. The impact of safety policies on the health and safety of migrant construction workers can be divided into unfair standards (Dutta, 2017) and breaches of safety policies by construction companies/contractors/individual employers (Díaz Fuentes et al., 2016). 59.2% of respondents illustrated that there was a complete safety policy in their companies, but only 35.8% of respondents thought the safety policies were effectively implemented. From these two results, it can be concluded that there is a lack of comprehensive safety policies in the NZCI to regulate the safety awareness and behaviour of CMCWs. Additionally, the effective implementation of safety policies within the industry requires further enhancement. The effective implementation of safety policies serves as a critical indicator that influences the safety outcomes for CMCWs. The effective implementation of safety policy could be affected by different factors (Hargreaves et al., 2019). CMCWs often lack knowledge and understanding of safety policies in the NZCI. For instance, they typically receive safety policies from site managers rather than by accessing the official safety regulations issued by the New Zealand government. There is a certain difference between these two safety policies. For instance, CMCWs often struggle to obtain information about their legal rights and interests in the event of a safety accident, based on the safety policies issued by the company. In addition, some migrant construction workers were reluctant to follow complex safety regulations due to a lack of safety awareness (Chávez and Altman, 2017). This means that there is an inherent association between personal variables and safety policy. For instance, in this study, 36% of respondents mentioned that they had to violate safety policies to finish the construction work on time. This indicates that in the NZCI, the implementation of safety policies needs to be adapted to fit the

specifics of practical construction projects. On one hand, construction companies should develop appropriate safety plans and policies aligned with those established by the New Zealand government. Site managers should enhance site management and supervision following these safety plans and policies. Additionally, CMCWs should bolster personal variables (like safety awareness and safety behaviours) while improving work efficiency without compromising safety policies. Implementing these strategies will effectively improve the safety outcomes for Chinese migrant workers in the NZCI.

The P-value from Communication Barriers (C) to Safety Outcome (O) is 0.822 which is greater than 0.10. This means that communication barriers (including language barriers) were not significantly associated with the safety outcomes of Chinese migrant workers in the NZCI. However, this result contradicts existing research that reports a significant association between language barriers on the health and safety of migrant construction workers (Cruz et al., 2018, Fernández-Esquer et al., 2020, Kim et al., 2020). While 46.7% of respondents acknowledged that language barriers can increase their safety risks, they also indicated that there were no communication barriers between them and their supervisors or colleagues in construction companies. Nevertheless, a quarter of respondents indicated that language barriers impact communication and safety in their workplace. One explanation for this situation is that the workers participating in the study predominantly worked for ethnically Chinese-run companies where language barriers were mitigated due to common language communication on the worksite. This study found that Chinese migrants who work in the NZCI may choose Chinese construction companies or companies with Chinese leaders as their priority work. This process can reduce the impact of language barriers on their safety factors as they can communicate in their native language. This inference has been confirmed by other scholarly literature. For example, many construction companies will recruit bilingual workers or managers to lessen the effect that language barriers have on the safety of migrant construction workers (Roelofs et al., 2011). Bilingual managers or workers can mitigate communication barriers among migrant construction workers with different

languages on the construction site and can even eliminate safety hazards in some cases (Fellows et al., 2023, Oswald et al., 2019, Vignoli et al., 2021). In addition, 76.67 % of respondents in this questionnaire survey had a bachelor's degree or higher education level. This situation also indirectly affected the results of the questionnaire survey. This suggests that language barriers affect the safety outcomes of Chinese migrant workers in the NZCI in a non-traditional manner. Language barriers affect the safety outcomes of Chinese migrant workers not by influencing communication and culture, but by limiting their access to safety policies and hindering their participation in safety training within the NZCI. This conclusion explains why communication barriers, cultural differences, and safety training were not significant factors in the PLS-SEM model. On the one hand, overconfidence of migrant skilled workers can lead them to overlook the importance of safety training (Arcury et al., 2014). 91.7% of respondents in this questionnaire survey had around 5 years working experience in the construction industry. Many CMCWs may ignore the effectiveness of safety training in improving their health and safety. On the other hand, the lack of bilingual safety training can diminish the safety knowledge and awareness of migrant construction workers (Moyce and Schenker, 2018). However, whether this conclusion applies to CMCWs in New Zealand remains to be further explored. Therefore, in the next chapter (Chapter 5), the impact and effectiveness of safety training are explored as part of the safety improvement strategy for Chinese migrant workers in NZCI.

4.6. Conclusion

This study explores the relationship between five safety influencing factors (safety policy, safety training, communication barriers, cultural differences, and personal variables) and the safety outcome of Chinese migrant workers in the NZCI. The study adopted a questionnaire survey as the data collection method and utilised Partial Least Squares Structural Equation Modeling (PLS-SEM) to construct a theoretical model by Smart PLS 4.0 data analysis software. Based on a series of adjustments and verification of the model, it is ultimately proved that both the reliability and validity of this theoretical model satisfies the criterion of the PLS-SEM. The research results demonstrate that safety

policies and personal variables have a significant influence on safety outcomes. On the other hand, safety training, communication barriers, and cultural differences have an insignificant association with safety outcomes for CMCWs. Whether safety policies are effectively implemented has a positive and significant impact on the safety outcomes of migrant construction workers. Completed and effectively enforced safety policies are the most significant factor in improving safety outcomes for migrant workers in the construction industry. Moreover, personal variable is another significant influencing factors for the health and safety of CMCWs. This study demonstrates the strong relationship between the effectiveness of safety policies and the personal variables of Chinese migrant workers. Although the results of this research show communication barriers have a non-significant relationship with safety outcomes of Chinese migrant workers in the construction industry, the co-linguistic cultural work environment of the sample group may affect the data results and conclusion. This means that many Chinese migrant workers prefer to choose construction groups with the same language and culture, which can create an "illusion" that the communication barriers do not impact migrant construction workers. The findings of this study reveal that language barriers affect the safety outcomes of CMCWs in NZ not through communication in the construction sites but through alternative pathways. Consequently, future research should explore the forms of language barriers on the health and safety of CMCWs.

Dedicated workplace safety frameworks for Chinese migrant construction workers (CMCWs) remain largely unexamined in the global construction industry. Building on the concepts from Chapters 3 and 4, the next chapter aims to develop a novel safety platform specifically for CMCWs and assess its feasibility and effectiveness.

CHAPTER 5

Safety improvement strategy for CMCWs: a novel safety platform prototype

This chapter is based on the following unpublished manuscript, which has been submitted for Journal review and consideration.

Guan, Z., Samarasinghe, D.A.S., Yiu, T.W., Ian Laird., and Reddy, R. Building Safety Bridges: A Comprehensive Exploration of a Health and Safety Platform for Migrant Construction Workers.

Abstract

There is a plethora of research highlighting numerous safety management strategies implemented in real-world construction projects. These include incorporating auditory or visual aids, utilising bilingual supervisors, and deploying visualization tools. Among these safety improvement strategies, the establishment of digital web safety platforms has emerged as a prevalent and practical solution. However, workplace safety frameworks designed specifically for CMCWs are still largely unexplored within the global construction industry. Following the concepts outlined in Chapters 3 and 4, the objective of this chapter is to establish a novel safety platform explicitly for CMCWs and to verify its feasibility and effectiveness. The study began with semi-structured interviews to collect data. Following this, the feasibility and effectiveness of the safety web prototype in real-world engineering scenarios were evaluated based on the assessments and evaluations provided by the interviewees. The findings from this chapter indicate that this web prototype contributes to enhancing the safety policy knowledge, safety awareness, and safety practical skills among CMCWs. The inclusion of safety incentives within this prototype represents an innovative aspect of the safety improvement strategy, effectively motivating independent participation of CMCWs in site safety management.

5.1. Background

Existing literature has demonstrated numerous strategies aimed at decreasing the safety risk on construction sites. For instance, aids such as audio, video, or pictures are the most direct and simple strategies to improve awareness of safety regulations for migrant construction workers (Díaz Fuentes et al., 2016). Another practice on construction sites to mitigate safety risks stemming from language barriers among migrant construction workers is the recruitment of bilingual individuals for positions such as foremen, chief engineers, or project managers (Oswald et al., 2019). Bilingual managers play a vital role in improving communication between migrant and native workers and also in shouldering the responsibility of interpreting safety policies for migrant construction workers experiencing language barriers (Fellows et al., 2023). However, bilingual supervisors who oversee multiple construction sites may be limited in their ability to effectively direct migrant construction workers in responding to emergency situation on-site incidents (Oswald et al., 2019). It is suggested that strengthening safety training improves the capacity of migrant construction workers to independently respond to on-site incidents (Dong and Platner, 2004). The content of health and safety training should focus on the professional skills, safety awareness, attitude, and behaviour of migrant construction workers (Mosly and Makki, 2021). The effective implementation of safety management platforms can reduce the occurrence of construction incidents and prevent negative outcomes in worksites (Hasan and Jha, 2013). A safety platform covers various aspects and plays a managerial role in improving the health and safety of construction workers from multiple perspectives. The strengths of effective safety platforms include strengthened safety management systems (Shan et al., 2022), improved safety supervision (Li et al., 2022), effective safety training (Shurong, 2011), and the enhancement of health and safety among migrant construction workers at current construction sites (Timoshkin, 2020).

5.2. Research gap and questions

The existing literature primarily concentrates on exploring the optimisation and enhancement of safety platforms for safety management and training (Shan et al., 2022, Shurong, 2011). However, there is a

lack of in-depth research on the strategies and effectiveness of safety platforms in promoting the health and safety of CMCWs (Liu and Lu, 2015). The following research questions were proposed in this study to narrow the research gaps.

- How does a safety platform improve site safety for migrant construction workers?
- What challenges does the safety platform face in improving the health and safety of migrant workers?

5.3. Research aim and objectives

The aim of this phase is to examine strategies for enhancing the health and safety of Chinese migrant workers in the construction industry. This chapter explores the efficacy of safety platforms in enhancing the health and safety of these workers and will address the following two research objectives.

a) To create an innovative safety platform for CMCWs, and

b) To explore the influencing mechanisms and effectiveness of this platform on the safety improvement of CMCWs.

5.4. Research Methods

This study utilised the qualitative method of semi-structured interviews to collect data. The method process can be divided into three phases. The research process is shown in Figure 5.1.

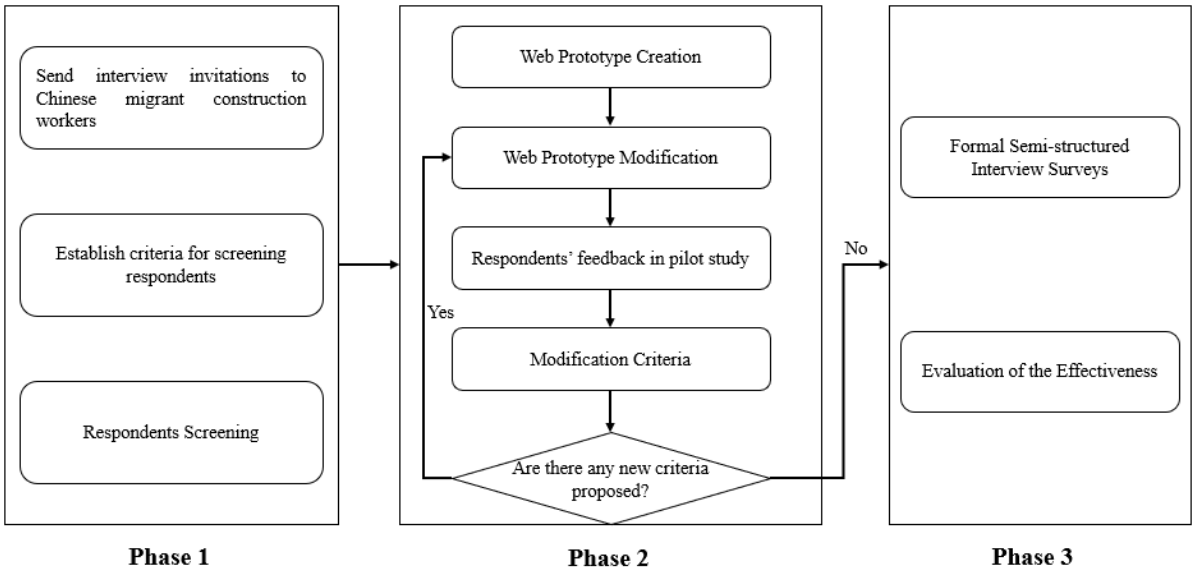

Figure 5.1. Overall research process

5.4.1. Phase 1. Recruitment and screening of CMCWs

In phase 1, invitation letters seeking participation were sent to Chinese migrant workers in the NZCI. Based on the definition in Chapter 2, respondents participating in interviews had to meet the following criteria.

1. The respondent has a current contract signed in the NZCI,
2. The respondent has a valid passport from mainland China, Hong Kong, Macau, and Taiwanese, and
3. The respondent has a legal visa in NZ.

There was no limitation on the specific occupation of the CMCWs to ensure an adequate sample size. This means that respondents could hold any position in the construction industry, such as labourers, project managers, engineers, architects, and so on. Researchers utilised the Site Safe database of Chinese migrant workers to extend interview invitations to individuals employed in the NZCI. Site Safe is a national not-for-profit membership organisation in NZ and plays a vital role in a comprehensive safety training service for construction workers (Site Safe, 2023a). Since 1999, Site

Safe has aimed to create a positive change in the health and safety culture within the NZCI (Site Safe, 2023a). Currently, Site Safe has a membership of 6,315 companies from construction and related industries in NZ (Site Safe, 2021). Therefore, Site Safe's database encompasses the contact information of numerous CMCWs. In this phase, invitation letters were sent to 8,337 CMCWs based on Site Safe's database. Once CMCWs expressed their willingness to participate in this interview study, they could contact the researchers via email, phone, or WeChat (the most popular connecting mobile social media for Chinese (Pang, 2022)). This study was evaluated by peer review and judged to be low risk (4000027904). Respondents who met the criteria and expressed a willingness to participate in this study were required to sign a consent form, which is shown in Appendix 3.

5.4.2. Phase 2. Creation of the web prototype

Phase 2 aims to establish and improve the web prototype. Various studies have proved that a feasible practical strategy for conducting in-depth explorations of research objectives is through building prototypes (Bradbury et al., 2014, Bradbury et al., 2018, Yardley et al., 2015). Therefore, a safety web prototype was developed through a website-building platform, Wix. Wix not only provides a user-friendly and intuitive website editor for ease of use but can also create custom services tailored to user requirements and unique characteristics (Wix, 2023). In this study, the upgraded version of Wix was used because of the more comprehensive functions offered when compared to the free versions. Three existing safety platforms in the NZCI were reviewed. and the key features of those platforms are presented in Table 5.1.

Table 5.1. Review results of different construction safety platforms in NZ

Platform production company	Key features	Reference
Site Safe	• Site Safety Card: Card expiry/ Training history/ Foundation Passport green	(Site Safe, 2023b)

	indicator (only if completed a Foundation Passport course). • Training tab • Resources tab • Products tab • Practical Safety Advice and Guides. • Latest in health and safety news. • Ask an advisor and contact us forms. • Contact us	
SignOnSite	• Registration & Attendance • Inductions • SWMS • Permits • ToolBox Talks • Data & Reporting • Procore Integration • Autodesk Integration • Emergency Management	(SignOnSite, 2023)
Site App Pro	• Corrective Actions • Form Builder and Scheduler • Site Inductions • Geo Location • Management Reporting • Offline Functionality • Contractor Management • Toolbox Talks • Near Miss Reporting • Pre-Starts • Risk Assessment & Hazard ID • Qr Code Sign in • Live Hazard Register • Group Functionality	(Site App, 2023)

	• Asset Registers • Dedicated Support • Visitor Management • Live Messaging • Vehicle & Plant Checklists	

According to Table 5.1, the existing safety platforms have various features that streamline on-site safety management and reduce safety management workloads and management hours. Those key features can be categorized into three main aspects: the safety knowledge module, the safety training module, and the on-site safety management module. Therefore, the web prototype developed in this study also incorporates these three features. This web prototype includes the following three stipulations to improve the health and safety of Chinese migrant workers.

a) The prototype should educate CMCWs on existing health and safety policies to improve their safety awareness and knowledge.

b) The prototype should include safety training functionalities to equip CMCWs with the necessary skills to effectively apply their safety knowledge in real-world projects.

c) The prototype should integrate safety management features to enhance on-site safety and mitigate the risk of safety incidents during construction.

The initial version of the web prototype consisted of three sections: (1) Health and safety policy, (2) Safety training, and (3) On-site safety management. The initial version of the web prototype is shown in the Appendix 4.

According to the research findings in Chapter 4, personal variables are significant factors affecting the health and safety of Chinese migrant workers in the NZCI. Personal variables include safety awareness, safety knowledge, safety compliance, etc. The safety platform serves as a strategic solution to enhance

the health and safety of construction workers by improving on-site safety management (Shan et al., 2022). This means that although the safety platform cannot directly improve the personal variables such as safety awareness of CMCWs, the personal variables of CMCWs can be addressed through different functions in the safety platform. The specific improvement methods corresponding to each function are explained in detail in sections 5.4.2.1-5.4.2.3.

5.4.2.1. Section 1. Health and Safety Policy

Inadequate knowledge of safety policies can negatively impact the health and safety of migrant construction workers (Dutta, 2017, Ibarra-Mejía et al., 2021). A lack of knowledge about local legislations in the host country, such as construction safety regulations or compensation regulations, is one of the influencing factors for the health and safety of migrant construction workers, and this lack hinders their capacity to effectively safeguard their rights to safety (Lay et al., 2018, Orrenius and Zavodny, 2009). The Health and Safety at Work Act (HSW Act) is the basic official safety policy for reducing workplace injuries in the NZCI (Site Safe, 2020). Therefore, the HSW Act is incorporated into the health and safety policy section in this web prototype, allowing respondents to inquire the safety legislation in the NZCI. According to the research results in Chapter 4, CMCWs lack the knowledge of safety policies and their legal rights (like compensation, right to appeal, right to report) in NZ. This function can improve their safety knowledge and awareness of the safety policies within the NZCI.

5.4.2.2. Section 2. Safety training

Safety training is regarded as an effective strategy to improve the safety behaviours of migrant construction workers (Dong and Platner, 2004, Chan et al., 2016). Effective safety training can enhance the practical ability of migrant workers to apply learned safety information on actual construction sites (Hussain et al., 2020). The content of safety training should include knowledge of safety, the identification of on-site risks, and the training of professional skills (Mosly and Makki, 2021). Safety

training can comprehensively enhance the personal variables of Chinese migrant workers in the NZCI, including safety awareness, safety knowledge, and safety behaviour. Through the safety training function, CMCWs may develop a new understanding of their gaps in safety knowledge, awareness, and the need to correct irregular safety behaviour. In this web prototype, the quality of safety training outcomes was gauged by the respondent's accuracy in safety test questions. All the test questions are derived from the HSW Act. This section can be divided into three phases shown in Figure 5.2: pre-tests, safety knowledge cards, and re-tests.

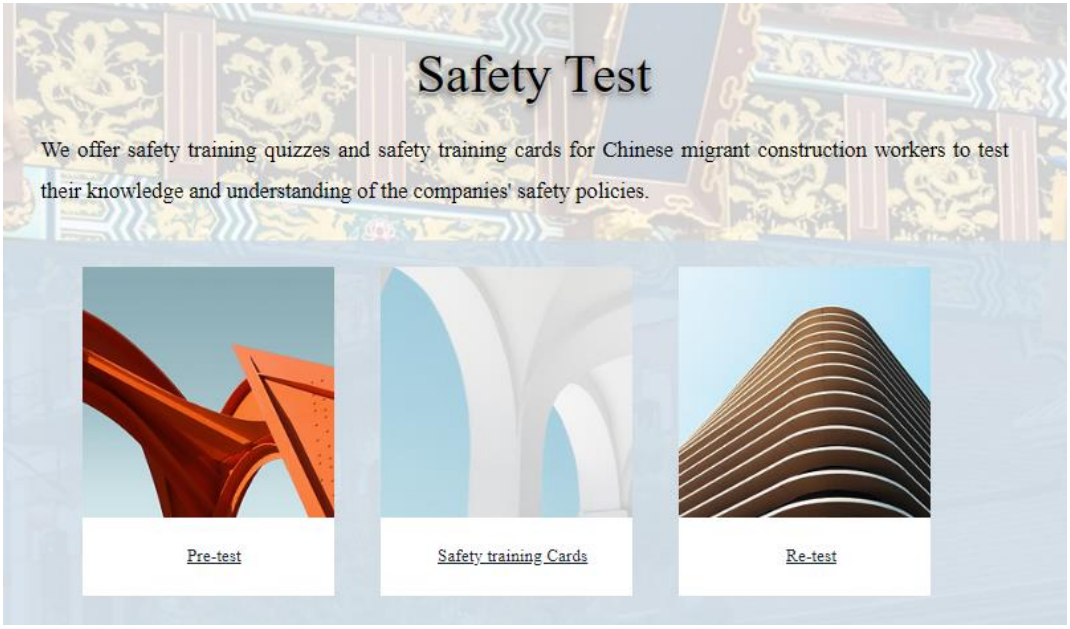

Figure 5.2 Safety Test section (*Source: Authors*)

Pre-tests can evaluate a respondents' existing safety awareness and knowledge. After receiving the new safety knowledge tutorial through safety training cards, the re-test can assess the ability of training transfer of respondents. The ability of training transfer refers to the ability of trainees to apply the knowledge gained from safety training effectively in actual construction projects (Hussain et al., 2020).

5.4.2.3. Section 3. On-site safety management

From Table 5.1, the most significant contribution of a safety platform is to strengthen on-site safety management, but establishing a complete on-site safety management system is an intricate process for

the safety platform (Hasan and Jha, 2013). Workers' accurate knowledge of the division of safety responsibilities can improve their safety compliance on construction sites (Wang et al., 2021). Hence, the initial version of the on-site safety management section in the web prototype included "Division of Safety Responsibilities" and "Safety Checklist". The contents of the "Division of Safety Responsibilities" and "Safety Checklist" are shown in Figure 5.3. These contents can provide CMCWs with a comprehensive understanding of the safety responsibilities of individuals (managers and migrant workers) and show clearer progress of safety inspections.

Location 位置	Safety manger 安全经理	Safety Responsibility Zone 安全责任区域	Status 状态	Register Person 登记人	Date 登记日期
Area a	XXX	Infrastructuree	Pass	XXX	
Area b	XXX	Interior Construction	Submit	XXX	
Area c	XXX	Site 3	Fail	XXX	

Division of safety responsibilities

Item Number	Inspector	Inspected Location	Date	Result	Status
Item 1	XXX	Site 1	2/03/2022	Qualified	/
Item 2	XXX	Site 2	15/06/2022	Unqualified	Need Rectification

Safety Checklist

Figure 5.3. Content of safety management section (*Source: Authors*)

5.4.3. Phase 2. Improvement of the web prototype

After developing the initial version of the web prototype, a pilot study was conducted for the improvement of the version of the web prototype. Participants in the pilot study were asked to provide feedback for improvements based on their working experiences. The interview questions are shown in Table 5.2.

Table 5.2. Interview questions in the pilot study.

Items	Question
Q1	Do you think this web prototype can improve your health and safety?
Q2	Do you think the safety policy section will satisfy your safety requirements?
Q3	Do you think the safety training section will satisfy your safety requirements?
Q4	Do you think the on-site safety management section will satisfy your safety requirements?
Q5	What other sections do you think are needed to meet your safety requirements?

A total of 10 interviewees participated in the pilot research. Due to ethical review requirements, the personal information of the respondents cannot be listed in detail. Among the 10 participants, 5 were construction workers, 2 were site managers, and 1 was employed by an official department of the NZCI. Six of the participants reported having more than 5 years of industry experience, while the remaining four had less than 5 years of experience. The feedback results (shown in Table 5.3) were the basis for developing modification criteria and strategies. Subsequently, the web prototype was adjusted in line with the modification criteria, and additional CMCWs were invited to reassess the revised version. This iterative process continued until no further new modification criteria were proposed. The modification criteria and improvement strategies are shown in Table 5.4.

Table 5.3. Feedback on improving the web prototype.

Interviewee	Feedback
I_1 & I_2	This prototype is very good and is very helpful for improving my safety awareness and knowledge. The disadvantage is that the functions are a bit limited, with only three features. Hope more features can be developed.
I_3 & I_4 & I_5	This prototype should be switched to Chinese and English modes. This function is missing from the current version. Many Chinese workers in NZ do not speak English well, which is why they only choose to work in Chinese companies. This should be noted when designing prototypes.

I_6	In the safety policy section, the HSW Act alone is not enough. The HSW Act regulate general safety standards for all industry in NZ. The prototype needs more specific safety regulations for the construction industry.
I_7	I don't think these sections can engage Chinese workers to participate. Researchers need to add more sections to motivate Chinese workers to use this prototype.
I_8	In the safety training section, researchers should add more training on specific safety operations in the construction.
I_9 & I_{10}	In the safety policy section, the HSW Act is still in English. This will be difficult for Chinese workers to read. They won't have the patience to read the entire Act. More workers will just follow what managers tell them about legal norms.

Table 5.4. Modification criteria and improvement strategies of the web prototype.

Modification Criteria	Improvement Strategies
The web prototype should have Chinese-English conversion function.	Change the web prototype to Chinese and English versions and allow users to switch between the two versions using a language conversion button.
Add more safety legislation in safety policy section.	This web prototype adds three more legislations in the safety policy section, which are "Your health and safety rights and responsibilities-Chinese", "Construction site safety manual-Chinese", and "Health and Safety in Employment Regulations 1995".
Add specific safety construction training items based on the legislation and Act.	Added knowledge points and training questions on working at height, use of safety equipment, use of power tools, hearing protection, and dust.
Add another section to motivate Chinese migrant workers to use this web prototype.	Added safety incentive section to motivate Chinese migrant workers to use this web prototype through positive safety incentives like reputation and bonus.

According to Table 5.4, this web prototype has undergone four significant improvements. Firstly, a language conversion button was added in the web prototype, enabling users to switch between the Chinese version and the English version independently (shown in Figure 5.4).

Figure 5.4. Web capture for language conversion button (*Source: Authors*)

In addition, three safety regulations or manuals were incorporated in the safety policy section to supplement the HSW Act in offering legal safety knowledge to Chinese migrant workers in the NZCI. The "Your health and safety rights and responsibilities-Chinese" and "Construction site safety manual-Chinese" were provided by WorkSafe (Worksafe, 2020). Although there is a dedicated section on the WorkSafe official website, many respondents claimed to be unaware of this information. Both documents are presented in the Chinese language and published on the WorkSafe official website, making them suitable for Chinese migrant workers to read and study. As a result, this study added these two documents in the safety policy section to enhance the safety knowledge of CMCWs who access the web prototype. Moreover, "Health and Safety in Employment Regulations 1995" is legislation to reinforce the HSW Act (Southwell, 2022) and to further explain the risks and

responsibilities of employees, contractors, and members of the public (New Zealand Legislation, 2017). Hence, this web prototype also added this legislation as an additional document in this section. The revised version of the safety policy section is shown in Figure 5.5.

Figure 5.5. Comparison of initial and final versions of the safety policy section (*Source: Authors*)

With improvements made to the safety policy section, corresponding revisions should be made to the test questions within the safety training section. Based on the modification criteria, the updated test questions should not only encompass education on safety regulations but also cover knowledge points related to CMCWs' practical work skills. In the construction industry, various hazards can lead to both fatal and non-fatal incidents (Carter and Smith, 2006). The top four safety-related hazards, among the various on-site hazards, are falls, falling objects, the use of power tools, and hearing loss (Branz, 2021). Therefore, the safety test questions in this section cover the knowledge points related to those hazards to strengthen the safety knowledge and awareness of Chinese migrant workers. The quiz questions and correct answers are shown in Table 5.5.

Table 5.5. Quiz questions in the safety training section (*Source: Authors*)

Items	Safety training quiz	Multiple Options
Q1	What does the company's health and safety policy include?	a) Provide a safe workplace, safe equipment, appropriate PPE and insist on safe work practices at all times, for both employees and subcontractors. b) Working together to eliminate on-site injury. c) Providing effective safety training. d) Encourage open communication and a "just culture" attitude to Health and safety.
Q2	Which of the following is true about a worker's right to cease or refuse to perform unsafe work?	a) A worker may cease, or refuse to carry out, work if the worker believes that carrying out the work would expose the worker, or any other person, to a serious risk to the worker's or other person's health or safety arising from an immediate or imminent exposure to a hazard. b) A worker can refuse to work without explaining the situation to a supervisor. c) A worker can refuse to do work that, because of its nature, inherently or usually carries an understood risk to the worker's health and safety. d) Workers are free to refuse all works.
Q3	Which of the following options are your rights when you encounter risks?	a) Discuss your concerns with your employer, manager, or safety manager. b) Refuse the work without any discussion with the supervisor. c) Report to the relevant agency or authority. d) Refuse the work that has inherent risks or work that all practicable steps have been taken to prevent harm from that hazard.
Q4	Which of the following are the responsibilities of workers at work?	a) Take reasonable care for his or her own health and safety.

		b) Take reasonable care that his or her acts or omissions do not adversely affect the health and safety of other persons. c) Comply, as far as the worker is reasonably able, with any reasonable instruction that is given by the person conducting a business or undertaking (PCBU). d) Co-operate with any reasonable policy or procedure of the PCBU relating to health or safety at the workplace that has been notified to workers.
Q5	Which of the following options need to be considered when working on a roof?	a) Consider the location and provision of anchorage points for safety harness systems or safety nets. b) Prepare the area below the roof to provide a firm and level support for mobile elevating equipment such as a scissor lift or cherry picker. c) Provide a guardrail around the perimeter. d) Consider providing permanent access and edge guard railing to the roof.
Q6	Which of the following options are the functions of hard hats?	a) Against being hit or struck by falling, fixed, moving or protruding objects. b) Against falling from the heights. c) Against coming in contact with electricity. d) Against to be exposed to UV, weather, and extremes of temperature.
Q7	Which of the following options is false about electrical equipment?	a) Consider all electrical wires and equipment live until they are tested and proven otherwise. b) Inspect cords, plugs and electrical equipment before each use. Repair or replace damaged equipment immediately. c) Use outlets or cords that have exposed wiring.

		d) Use ladders made with non-conductive materials (e.g., fiberglass).
Q8	Which of the following options can prevent noise-induced hearing loss?	a) Wear proper hearing protection (earmuffs or plugs) in noisy environments or when doing noisy jobs. b) Choose protection that fits and feels comfortable for long periods of wear. c) When you could bear the noise conditions, you need not wear hearing protection. d) Keep tools and equipment maintained – some equipment is noisier when not kept in good order.

Finally, a safety incentive section was added to motivate more CMCWs to use this web prototype. Safety incentive strategies are seen as a common method to motivate construction workers (Zulkefli et al., 2014). The forms of safety incentives are diverse in construction and include both financial incentives and non-financial incentives (Hasan and Jha, 2013). Financial rewards or penalties are the safety incentives that exert the most influence on the safety compliance of CMCWs as their primary objective is to earn more money (Zhang et al., 2022). In the safety incentive section, Chinese migrant workers received scores corresponding to their performance in the "safety training section" and "on-site safety management section". The top three Chinese migrant workers with the highest scores were awarded bonuses. The content of this section is shown in Figure 5.6.

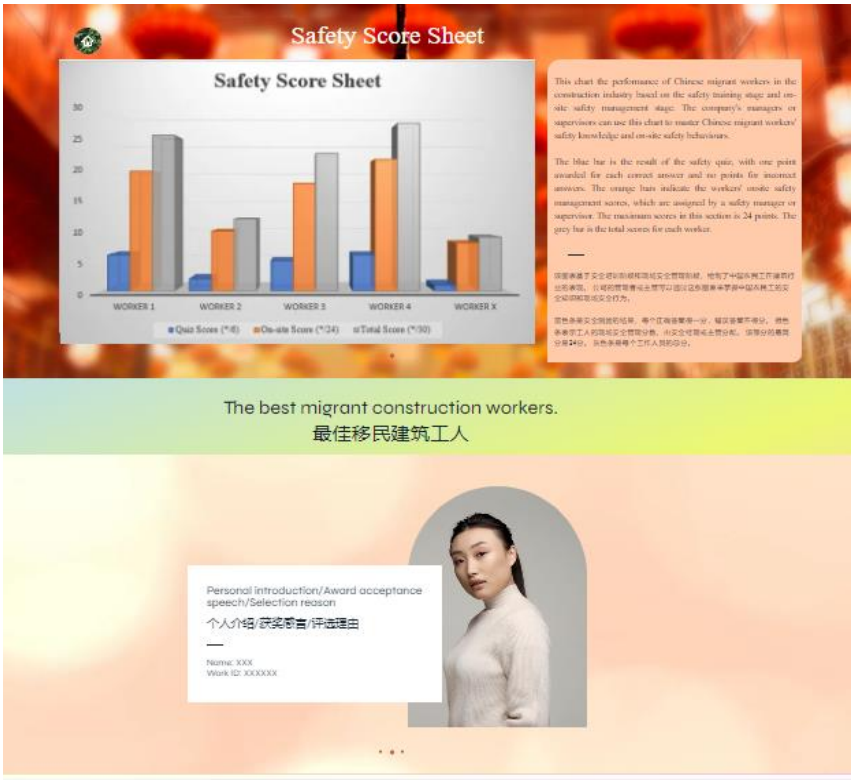

Figure 5.6. Safety incentive section in the web prototype (*Source: Authors*)

After the modifications were completed, five consecutive interviewees affirmed that the current version of the web prototype adequately met their safety requirements, and they did not propose any new improvement suggestions. Therefore, this version was finalised and implemented and evaluated. The final version of the web prototype is shown in the Appendix 5.

5.4.4. Phase 3. Interviews based on the final version of the web prototype

Twenty-two Chinese migrant workers who accessed the web prototype participated in the semi-structured interviews. Respondents were asked about the effectiveness of the web prototype in enhancing the health and safety of Chinese migrant workers. The interview questions are shown in Table 5.6. Critical analysis was conducted to assess the effectiveness of the web prototype based on the interview results. Subsequently, researchers leveraged the result of the analysis of the web

prototype as a theoretical basis to conduct an extensive discussion on the effectiveness of the safety platform in improving the safety performance of Chinese migrant workers.

Table 5.6. Interview questions in formal experiments.

Items	Question
Question 1	Please share your opinion on whether you believe this web prototype is effective in enhancing your health and safety.
Question 2	In what specific way do you think this web prototype improves your health and safety? (such as improvements in safety awareness, safety behavior, safety knowledge, etc.)
Question 3	Do you think this web prototype can effectively improve the health and safety of Chinese migrant workers in actual construction projects?

5.5. Results

Feedback from respondents on the effectiveness analysis of the web prototype and the outcomes of the two safety training tests were analysed. The detailed results for each stage are shown below.

5.5.1. Safety training results

The process of the safety training section in the web prototype can be divided into three stages: 'Pre-tests', 'Safety Training Cards', and 'Re-tests'. The test questions are shown in Table 5.5.

The first question aimed to ascertain the safety policies implemented by the respondents' companies. The results are shown in Table 5.7. All respondents expressed their companies' commitment to providing a safe workplace, safety equipment, and safety training. Fourteen respondents stated that their companies were dedicated to minimizing on-site injuries. 16 respondents demonstrated that their companies fostered positive communication to improve the health and safety of Chinese migrant workers.

Table 5.7 The results of Q1

Options in Q1	Respondents	Frequency / (out of 22 respondents), %
a) Provide a safe workplace, safe equipment, appropriate PPE and insist on safe work practices at all times, for both employees and subcontractors.	22	100%
b) Working together to eliminate on-site injury.	14	64%
c) Providing effective safety training.	22	100%
d) Encourage open communication and a "just culture" attitude to Health and safety.	16	73%

Q2 to Q8 encompass practical site safety knowledge related to falls, falling objects, the use of power tools, and hearing loss. The results of the safety training in "Pre-tests" and "Re-tests" are shown in Figure 5.7 and Figure 5.8. Figure 5.7 shows the percentage of respondents who answered correctly across the two tests and Figure 5.8 illustrated the accuracy of each question in the two tests.

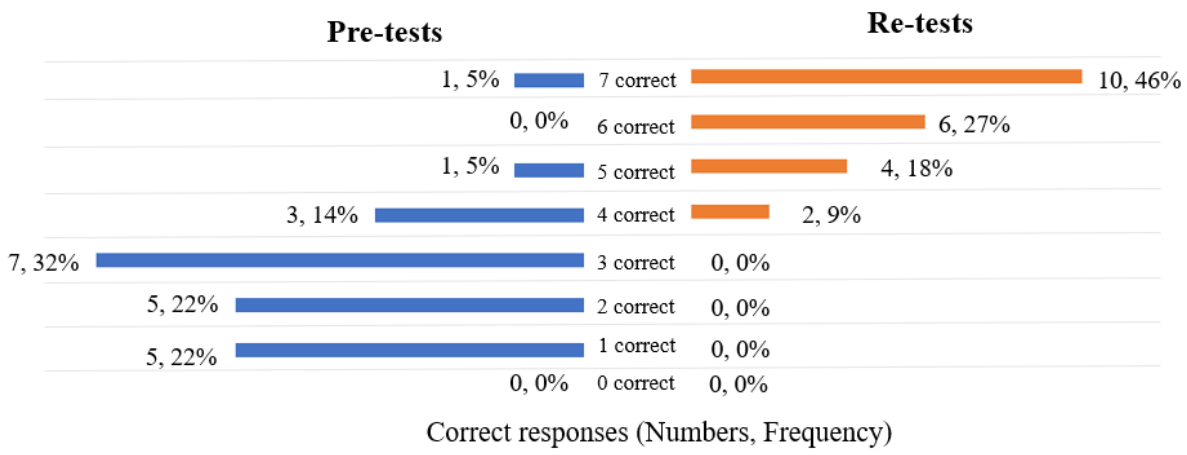

Figure 5.7 Number and proportion of correct responses for all questions (*Source: Authors*)

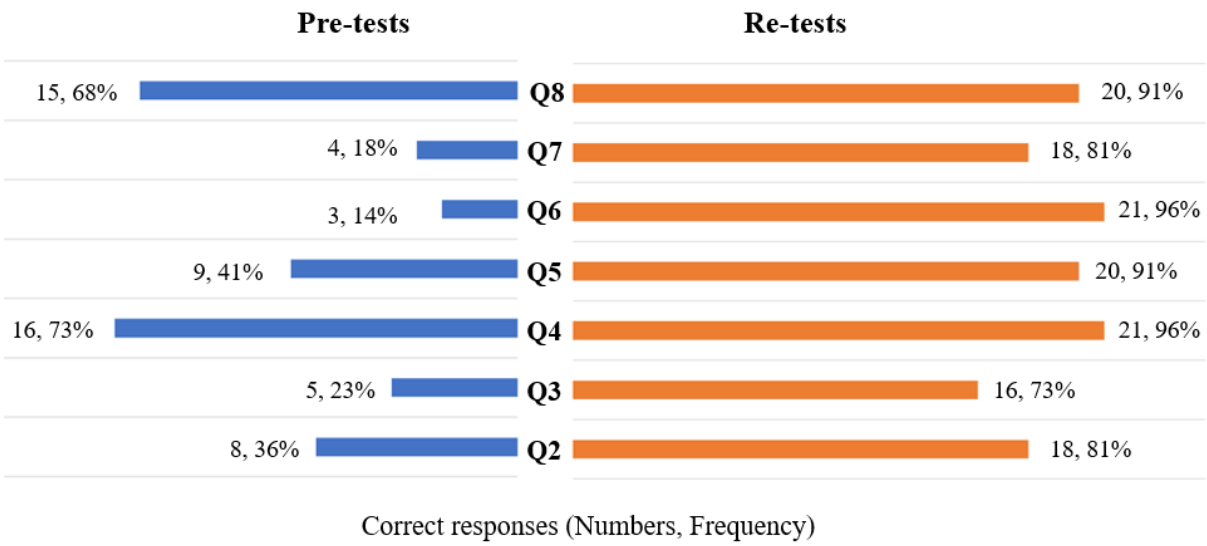

Figure 5.8 Number and proportion of correct responses for each question (*Source: Authors*)

The results show that prior to participating in the safety training section of the web prototype, 32% of all respondents (7 individuals) could only answer 3 questions correctly. In the pre-tests, individuals who only answered one or two questions correctly held the second position, each with five people. After learning about hazards from the safety training cards, 46% of respondents (10 individuals) answered all the training questions correctly in the re-tests. 27% of respondents (6 individuals) provided an incorrect response to only one question. In addition, Figure 5.8 showed the accuracy of each question in the pre-tests and re-tests. The number of correct responses for each question increased after the safety training and the increased value is shown in Table 5.8.

Table 5.8. The increased value of correct responses for each question (*Source: Authors*)

Question	Increased Rate
Q2	45%
Q3	50%
Q4	23%
Q5	50%
Q6	82%
Q7	63%

Q8	23%

Among these questions, the accuracy rate for Q6 showed the most significant increase, reaching 82%. Q4 and Q8 had high correct response rates in the pre-tests, accounting for 73% and 68% respectively. In the re-tests, the proportion of respondents who correctly answered these two questions increased by another 23%. In addition, the correct response rates of other safety test questions (Q2, Q3, Q5, and Q7) also substantially increased by approximately 50%.

5.5.2. Qualitative feedback of the web prototype

The semi-structured interview aimed to explore the respondents' suggestions for the effectiveness of the web prototype for the health and safety improvement of Chinese migrant workers in the construction industry. While most of the respondents (16 individuals) recognized the effectiveness of this web prototype, 6 of them had doubts regarding the effectiveness and feasibility of the web prototype in improving the health and safety of CMCWs.

5.5.2.1. Positive qualitative feedback

A total of 16 out of 22 respondents approved of the web prototype. Respondents highlighted that the web prototype would contribute to improving the health and safety of CMCWs. The web prototype contains legal knowledge and practical safety manuals, which encompass essential knowledge points that CMCWs should be proficient in. The sentences in italics summarize the feedback provided by multiple respondents, with the notation "P1-22" in brackets indicating the opinions of the corresponding respondents.

> *"Many Chinese workers cannot read the English version of safety policies. This prototype, definitely, helped improve their safety knowledge." (P3, P5, P6).*
>
> *"What CMCWs often lack is not skills but knowledge. Many of them do not know the local laws and thus they are unable to safeguard their rights to safety." (P10, P 12, P19).*

"Many Chinese workers come to new countries, but they are not familiar with local safety regulations. They want to know relevant legal knowledge but many times they do not know where to get the corresponding knowledge." (P4, P18).

It was suggested that safety training plays an essential role in the safety platform in the construction industry. CMCWs are interested in safety training of this nature and are enthusiastic about acquiring relevant safety knowledge. It was reported that the safety training section in the web prototype can not only help them effectively review and consolidate their existing safety knowledge but also enhance their safety awareness.

"Safety training is necessary. It's good to take the quiz to make me re-think about these H&S clauses which I took for granted." (P1).

"Efficient. I think the Chinese and English versions of the test helped me better understand the test questions. Plus, this form of quiz solidifies my knowledge and tells me what I should pay attention to in the venue." (P3, P16, P22).

"Yes, I think this training can effectively increase prevention awareness." (P14).

Furthermore, the inclusion of the safety incentive section was seen as a novel feature of this web prototype. Many respondents also gave positive recognition to this section.

"This is an interesting section for a safety platform. Typically, a company doesn't pay much attention to incentives because it is hard to implement incentives, especially financial incentives effectively." (P7, P10, P13).

"Absolutely feasible. Chinese migrant workers tend to prioritize financial incentives, such as bonuses, wage increases, and rewards." (P15, P16, P18, P19).

"If the company is willing to add incentive mechanisms in the safety platform, many Chinese construction workers will actively participate in the safety platform. The prospect of earning additional income, coupled with the opportunity to acquire safety knowledge, is anticipated to bring considerable satisfaction to the workers." (P21, P22).

Most of the respondents indicated that the Chinese version of the web prototype served as a significant feature to assist CMCWs in acquiring safety knowledge and comprehending on-site safety management.

> *"I really like this Chinese version of the web prototype. Many construction platforms in NZ are available only in English. This is not conducive to some Chinese workers whose English is not good. The Chinese version of the safety platform is easier for most Chinese workers to operate." (All participants).*

5.5.2.2. Negative qualitative feedback

While most respondents acknowledged the effectiveness of the web prototype in improving the health and safety of Chinese migrant workers, 6 participants expressed doubts about its effectiveness in practical projects. It was pointed out that in actual projects, CMCWs had a low level of safety awareness, which resulted in weak participation in safety platforms. The limited engagement and weak participation of CMCWs significantly reduced the effectiveness of the knowledge-based safety web prototype.

> *"Many Chinese workers have low safety awareness. They only care about their income and working hours. As long as the company gives them a lot of money, they don't care about safety." (P2).*
>
> *"Chinese migrant workers often lack the initiative to utilise safety platforms. Their strenuous work at the construction site leaves them fatigued, making it nearly impractical to anticipate them studying during breaks." (P8, P9).*
>
> *"In their view, what is important is the arrangement of the on-site managers or supervisors. They don't need to visit safety platforms. They just need to work as directed by their managers." (P20).*
>
> *"I am too tired every day and do not have extra energy or time to visit this prototype. Unless my company gives me an extra salary or vacation." (P11).*

Two participants questioned the effectiveness of the safety training section in this web prototype. In their opinion, the number of safety test questions is one of the factors affecting the effectiveness of the

safety training section in the web prototype. Insufficient test questions may not yield the training effect, while an excessive number of test questions may reduce CMCWs' completion rates and participation.

> *"Insufficient questions may hinder the training effectiveness, while too many questions will discourage Chinese migrant workers participants from continuing" (P2, P11).*

On the other hand, the safety awareness of employers or supervisors of Chinese migrant workers also directly impacts the effectiveness of safety platforms. As construction team supervisors, three respondents (P9, P17, P20) stated that supervisors often prioritize assessing whether workers can complete safety training courses and pass safety training tests provided by government agencies, without necessarily focusing on whether Chinese migrant workers can master safety knowledge. Construction supervisors focused more on the certificate in safety training courses. Moreover, respondents also questioned whether the web prototype can bring profits to construction companies. One participant insisted that sufficient financial support was a vital resource for maintaining the effective operation of the safety platform.

> *"When workers complete a safety training course, like the course arranged by Site Safe, they will receive a certificate of completion indicating they are ready to work. . .. The key point is the certificate, as long as they have the certificate, I will hire them." (P17).*

> *"This prototype uses incentives to motivate Chinese workers to participate in the platform, but how to ensure the interests of the company? Companies or managers are not willing to pay for this cost." (P9, P20).*

> *"How will your platform make money, and how will you ensure that your prototype operates effectively? This is the key factor you should consider. I suggest that you can expand from two aspects: charging advertising fees or government subsidies." (P20).*

5.6. Discussion

5.6.1. Quantitative results discussion

Through qualitative findings in two safety tests in the safety training section, existing safety knowledge level and training transfer ability of CMCWs were assessed. The quiz questions in the safety training

section were shown in Table 5.5. This study explores the current safety knowledge level and learning ability of Chinese migrant workers in the NZCI based on pre-tests and re-tests in the safety training section of the web prototype. The quantitative results show that in the pre-test, only 1 individual (5% of the respondents) was able to correctly answer all test questions related to safety regulations and on-site practical skills knowledge. Most respondents (32%) could answer 3 test questions correctly. Despite all respondents indicating that they have undergone safety training courses, many CMCWs either do not have crucial safety knowledge or possess incorrect safety information. For instance, only 3 out of the 22 respondents (14%) mastered all the functions of the helmet on construction sites (Q6).

CMCWs had extremely strong learning and training transfer capabilities. For instance, after participating in the safety training in the web prototype, the number of correct responses increased to 10, representing a growth rate of 41%. Simultaneously, the number of participants who answered only one wrong question in the test rose from 0 to 6, indicating a growth rate of 27%. All respondents demonstrated proficiency in answering more than 4 test questions correctly (totalling 7 questions).

5.6.2. Qualitative results discussion

The qualitative findings reflected challenges and solutions to improve the effectiveness of safety platforms in enhancing the health and safety of Chinese migrant workers in the construction industry. The research results show that while some interviewees questioned the effectiveness of the safety platform in improving the health and safety of CMCWs, 73% of respondents believed that the web prototype had the potential to enhance the safety knowledge and awareness of Chinese migrant workers on construction sites.

The respondents believed that compared with other overseas safety platforms, this web prototype adopted both Chinese and English to decrease the negative effects of language barriers for Chinese

migrant workers. Language barriers have consistently been regarded as a significant factor affecting the health and safety of migrant construction workers (Kim et al., 2020). All interviewees highlighted that language barriers are a common challenge for many CMCWs. However, a shared language and cultural environment can reduce safety hazards for migrant workers on construction sites (Roelofs et al., 2011).

Most Chinese migrant workers tend to prioritize employment on construction sites either owned by Chinese overseas construction companies or have Chinese supervisors. Compared with obstacles in communication, the impact of language barriers on CMCWs is more to hinder the acquisition of safety knowledge and safety information. For instance, due to language barriers, it can be challenging for migrant construction workers to independently access compensation information, and the acquired information may also contain misunderstandings or disinformation (Premji et al., 2023). This web prototype not only provides CMCWs with safety legislation but also adds a Chinese version of rights and responsibility documents and on-site work manuals tailored to local conditions. Consequently, adopting bilingual versions of safety platforms and providing translated versions of safety legislation/practical skills manuals are regarded as vital features to improve the effectiveness of safety platforms. This type of safety platform can assist CMCWs access and comprehend local safety regulations, which can ultimately improve the overall health and safety levels of this demographic.

Moreover, safety training is a long-term process for enhancing the safety awareness and conduct of construction workers (Nielsen et al., 2023). Some participants reported that small safety quizzes not only facilitate the acquisition of new safety knowledge but also rectify previously incorrect safety perceptions. However, managers and workers do not have identical emphasis on the effectiveness and outcomes of safety training (Namian et al., 2020). Although effective safety training outcomes should

lead to construction workers being able to transfer safety training knowledge into practical application on construction sites (Nielsen et al., 2023), some respondents indicated that company managers focus more on whether these CMCWs possess safety certificates. Three interviewees in this study demonstrated that periodically, Chinese migrant workers are required to participate in the safety training courses mandated by the government or their company, to obtain safety knowledge and safety certificates after the courses. For example, in NZ, graduates will receive a New Zealand Qualification Authority-recognised New Zealand Certificate in Workplace Health and Safety Practice (Level 3) (Site Safe, 2021).

It is problematic to assess the safety training transfer ability of CMCWs by safety certificates alone. For instance, all the participants in the semi-structured interviews had a New Zealand Qualification Authority-recognised New Zealand Certificate in Workplace Health and Safety Practice (Level 3) but their average correct rate in the safety pre-test in the web prototype was only 38.96%. Hence, construction companies not only need to review the safety certificates of CMCWs as a basic requirement but also should increase the frequency of safety training to improve the accuracy of safety knowledge and education. According to the quantitative results, the test accuracy rate of CMCWs increased significantly to 87.01% after taking the small-scale safety training. The interview results show that CMCWs prefer the daily small-scale safety training provided in this web prototype as this type of safety training can improve safety awareness without increasing too much work stress. This kind of platform can not only decrease the costs of safety training but also fundamentally elevate safety awareness and education level proficiency among CMCWs.

Some respondents expressed negative opinions on the effectiveness of this web prototype in improving the health and safety of CMCWs. It was reported that CMCWs were unlikely to spend their personal

time browsing or using safety platforms, attributing this reluctance to a lack of safety awareness and motivation. Respondents also raised concerns about the feasibility of the web prototype to generate financial benefits for construction companies. Therefore, this study proposed the following two strategies to address the concerns of opponents.

The web prototype added a safety incentive section to motivate CMCWs to participate in the safety platform. The primary objective of migrant workers is to gain financial benefits (Afuye et al., 2022). The interview results show that safety incentives, especially financial incentives, can significantly increase the involvement of CMCWs. However, construction workers may conceal or provide false information about safety incidents to obtain high financial benefits (Kim et al., 2019). Hence, this study suggests the use of small-scale, multiple-time financial and non-financial safety incentives to motivate CMCWs to actively engage with safety platforms.

In addition, while this web prototype cannot directly contribute to high profits for construction companies, it can indirectly mitigate project safety costs by improving the health and safety of CMCWs. The research results indicate that current safety platforms primarily cater to site managers and ignore the potential contribution of migrant construction workers in safety management. However, the participation of construction workers in site safety management is one of the effective strategies to improve the overall safety climate (LÓPez-Jacob et al., 2010). It is recommended that construction companies using this web prototype can seek financial support from local government safety management agencies or charge merchants by providing advertisement spaces to obtain financial benefits.

5.7. Implications

This study makes the following two contributions. Firstly, there is a lack of existing studies on the effectiveness of safety platforms in improving the health and safety of migrant workers in the construction industry. As globalization progresses, migrant construction workers have become essential labour resources. Existing research on safety platforms focuses more on leveraging intelligent or visual technologies like Building Information Modeling (BIM) or virtual reality (VR) to enhance safety monitoring or safety management evaluation systems (Bao et al., 2022, Bhagwat et al., 2021). In addition, most safety platforms are utilised by service on-site managers or companies in actual construction projects. There is a lack of research and existing safety platforms focused on improving the knowledge of safety policies and practical skills of migrant construction workers. Therefore, this study contributes to filling the research gap in this research area.

Secondly, this study developed a novel web prototype for examining the challenges associated with the application of safety platforms among CMCWs. The creation of this web prototype contributes to the design and evaluation of the existing technological safety platforms. While the web prototype in this study was specifically applied to CMCWs, subsequent research can utilise this web prototype as a model to explore the general rules of the effectiveness of safety platforms in enhancing the safety of immigrant construction workers of various nationalities.

5.8. Conclusion

In this study, a web prototype was developed through Wix (a website-building platform) to explore the effectiveness of the safety platform in improving the health and safety of Chinese migrant workers in the construction industry. The researchers used semi-structured interviews to gather feedback from CMCWs on how they perceived safety platforms. This study aims to narrow the research gap on the challenges encountered by CMCWs when implementing safety platforms. The research results will

serve as a theoretical foundation for exploring the universal patterns applicable to all migrant construction workers.

This study resulted in three key findings. Firstly, language barriers are one of the influencing factors affecting the health and safety of CMCWs. However, the repercussions of language barriers on this demographic are not readily significant in daily work communication as most CMCWs prefer to choose workplaces with a similar language environment or with Chinese managers. CMCWs express a desire to acquire safety knowledge about local safety regulations, such as rights protection and compensation. Nevertheless, language barriers significantly affect them in learning and understanding local safety regulations and codes of conduct. Due to a lack of multilingual safety legislation documents, it is hard for CMCWs to access Chinese versions of local safety regulations. The web prototype in this study not only provides bilingual versions of safety regulations/legislations but also furnishes practical construction skills manuals, and documents outlining the rights and responsibilities of Chinese migrant workers on the construction sites. This type of safety platform is convenient for CMCWs to access safety knowledge during on-site work.

Secondly, safety platforms and safety training have consistently been interconnected in the construction industry. The effectiveness of a safety platform in improving the health and safety of CMCWs is contingent on the intensity and frequency of safety training. While CMCWs are required to participate in recurring safety training courses, it is necessary to incorporate short-term, small-scale safety training tests to reinforce Chinese migrant workers' safety knowledge and rectify misconceptions. Hence, this study suggests a hierarchical approach to safety training knowledge and integrates it into the web prototype to achieve high-frequency safety training. This approach not only

improves the transfer of safety training information of CMCWs but also decreases construction companies' safety training costs.

Thirdly, this study added a safety incentive section to motivate CMCWs to participate in this web prototype. For CMCWs, safety incentives, especially financial incentives, are the most effective strategy to improve their participation in the safety platform and safety management. This study suggests using small-scale, multiple-time financial and non-financial safety incentives to ensure the feasibility of implementing safety incentives in the safety platforms. Moreover, the researchers propose that the web prototype could offer benefits to construction companies through government financial support or advertising fees to ensure efficient operation, but this research direction requires further investigation.

The next chapter presents research findings and recommendations for future studies aimed at enhancing the health and safety of Chinese migrant construction workers (CMCWs) in New Zealand.

CHAPTER 6

Conclusion and Recommendations

This chapter presents research findings and outlines recommendations for future research. The chapter begins by summarizing the research aim and objectives, followed by an overview of the doctoral research framework. It then illustrates the novel discovery and targeted initiatives. It then illustrates the contributions and the limitations of this research and offers insights into future studies, with a focus on improving the health and safety of CMCWs in NZ.

6.1. Introduction

This chapter commences with a comprehensive summary and analysis of all research findings conducted during the doctoral studies. Through the research results presented in previous chapters, this thesis delved deeply into the health and safety challenges faced by Chinese migrant workers in the construction industry and proposed a targeted solution. The entire research successfully achieved the three objectives proposed in Chapter 1 through the process of extensive theoretical exploration and specific practical experiments. The overall research objectives are:

1. To conduct systematic literature reviews to explore the safety influencing factors (Chapter 2).
2. To conduct systematic literature reviews to explore an existing solution strategy to enhance safety performance (Chapter 3).
3. To conduct an in-depth analysis of the key factors affecting the health and safety of CMCWs and identify the inter-relationship between each factor. (Chapter 4)
4. To explore a novel safety strategy to improve the health and safety of CMCWs. (Chapters 5)

Quantitative and qualitative research methods were employed in this doctoral thesis to comprehensively investigate the health and safety challenges and strategies for CMCWs. This study utilised different data collection and analysis methods across different studies to address the distinct

research objectives. The data collection methods encompassed systematic literature reviews (Chapters 2 and 3), questionnaire survey (Chapter 4), and semi-structured interview surveys (Chapter 5). The data analysis methods included the 5-step method in Chapter 2, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) in Chapter 3, the partial least squares structure equational modelling (PLS-SEM) in Chapter 4, and narrative analysis in Chapter 5. This chapter summarises all the key findings presented in the preceding chapters and offers a critical analysis and overall conclusion of the overall research results.

6.2. Summary of main findings and discussion

This thesis conducted extensive research and in-depth analysis in the field of health and safety of CMCWs. Using Chinese migrant workers in the NZCI as a case study, it explores the influencing factors, significance analysis, safety incentive strategies, and safety improvement solutions relevant to the health and safety of this population. Figure 6.1 illustrates the research framework and internal correlations of each stage throughout the doctoral research period. It demonstrates that research objectives 1 and 2 were achieved through a systematic literature review, which constituted the background research phase. The results of this stage include the definition of CMCWs, the three-factor levels impacting their health and safety, and the importance of safety incentives as a solution to enhance safety performance.

The results from stage 1 provided the foundation for the subsequent stages. For instance, the criteria for selecting respondents for the questionnaire survey and semi-structured interviews were based on the definition of CMCWs. Stage 2 accomplished research objective 3 by delving into the five key influencing factors and the interconnections, derived from the three levels of general influencing factors in stage 1. Stage 2 concentrated on analysing the significance of each influencing factor. In the solution phase (stage 3), this thesis proposed a novel web prototype with five functions, each corresponding to one of the five factors impacting the health and safety of Chinese migrant workers in

the NZCI. All main findings and innovative conclusions are described in detail in the following sections.

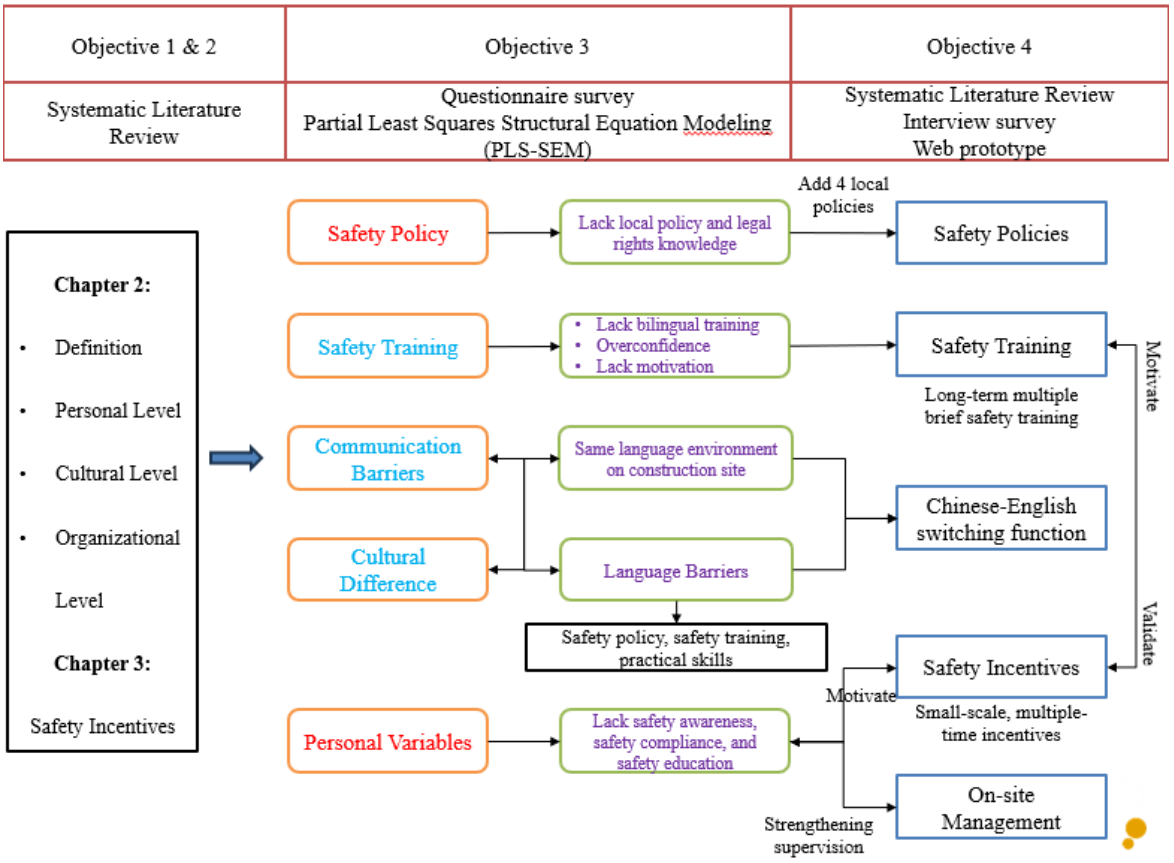

Figure 6.1 Overall research framework in whole doctoral study

6.2.1. Definition of CMCWs

The definition of CMCWs in this study is migrant workers who have Chinese citizenship and have legal work in the construction industry outside of their country of origin. This definition is formulated by combining the definitions found in various literature of Chinese migrants and migrant construction workers. Different migration studies classified migrant workers in various ways such as by migration regions, visa type, length of residence/work, autonomy and legitimacy (Anderson and Blinder, 2011, King et al., 2008). The definition in this thesis serves as a consolidated description of CMCWs based on these factors.

6.2.1.1. Migration regions

One of the most fundamental distinctions among migrant workers is the division between internal and external migrants based on their migration regions. In PRC, CMCWs typically refer to internal migration; that is, rural dwellers who move to urban areas for temporary construction work. However, there is a lack of a unified definition of CMCWs in other countries. Migration between countries is termed external migration or overseas migration. Migrant workers are employed or unemployed foreign-born persons of working age in the current residential country. The ethnic group is the key standard in classifying CMCWs in other countries. For instance, new Chinese migrants in NZ are Chinese groups from Hong Kong, Taiwan, PRC, and other countries like Malaysia or Indonesia. Overseas Chinese construction workers in Montenegro refers to Chinese ethnic groups from mainland China.

In addition, some scholars demonstrated certain differences between overseas Chinese of other nationalities and Chinese migrant workers. For instance, Korean-Chinese and Chinese migrant workers in South Korea have different Korean language proficiency and working behaviours, which may affect their health and safety like the fatality rate from occupational injury. Compared to local Chinese, migrant Chinese in Singapore mostly comprised young men engaged in the construction industry and have a limited awareness of safety risks. Hence, this study focused on international migration and the research subjects in this thesis were required to possess Chinese citizenship as this population may face a higher risk of injury.

6.2.1.2. Visa type and Length of residence/work

The length of residence/work for migrant workers in the host country is affected by the type of visa they hold. Several studies have distinctly categorized Chinese migrant workers by these two factors. For example, Rotimi et al. (2021) defined Chinese migrant workers as Chinese ethnic groups who hold

temporary working visas. Guo et al. (2015) defined Chinese migrant workers as immigrants who have been in NZ for over 12 months. Chinese migrant workers are also defined as individuals with temporary worker status, holding work visas valid for a maximum of five years (Kalir, 2009). There were two reasons why the research subjects in this thesis are not limited to visa type and work/residence length. The first reason is the expansion of the database to obtain more data samples. Second, these two data were incorporated into the demographic information of the respondents to explore the impact on the health and safety of CMCWs.

6.2.1.3. Autonomy and Legitimacy

Migrant construction workers may also include illegal immigrants and refugees (Douglas et al., 2019). However, this study excluded these two groups of migrants as it is difficult to collect effective information from them. The scope of this thesis is limited to CMCWs as its research subjects. Chinese workers who transitioned out of construction work are categorized as Chinese migrant workers rather than specifically as CMCWs. Hence, the research subjects had to have current legal work in the construction industry.

6.2.1.4. Summary of the definition

A standardized definition of CMCWs is proposed in this thesis and research subjects (respondents) participating in the research should possess the following three characteristics:

A. The sample group has a valid Chinese passport, including mainland Chinese passports, Hong Kong passports, Macau passports, and Taiwanese passports,
B. have a legal visa outside of their country of origin, and
C. have a current contract signed in the construction industry.

6.2.2. Factors affecting the health and safety of CMCWs

This study involved a comprehensive and systematic examination of the factors affecting the health and safety of CMCWs based on the research results from Chapters 2 and 3. The research findings

presented in Chapter 2 indicate that the influencing factors impacting the health and safety of CMCWs can be divided into three levels: organizational factors (macro-level), cultural factors (meso-level), and personal factors (micro-level). In Chapter 3, five factors which were mentioned most frequently by secondary data in Chapter 2 from the three levels of influencing factors were selected. An in-depth exploration was conducted in Chapter 3 regarding the inherent relationship between these 5 influencing factors and the safety outcomes for CMCWs.

6.2.2.1. Organizational Factors (macro-level)

Based on the research findings in Chapter 2, organizational factors included unfair policies or regulations, inferior quality of safety training, and exploitation. It is difficult for migrant construction workers to resist organizational factors like exploitation as employers may threaten them with unemployment, repatriation, or loss of future employment opportunities in order to coerce them into adhering to unfair safety policies. According to the results in Chapter 3, the p-value between safety policies and safety outcomes of CMCWs was 0.005 in the PLS-SEM model. This p-value is less than 0.01, which means that safety policies showed highly statistically significant safety outcomes for CMCWs.

In Chapter 5, the CMCWs stated that many companies in NZCI had safety policies committed to providing a safe workplace, functional PPE, and safety training. Some companies' safety policies may additionally pledge to enhance on-site communication as measures to reduce injury rates. The research findings indicated that a clear and well-established safety policy was one of the key strategies to improve safety outcomes for CMCWs. Moreover, some CMCWs noted that more stringent enforcement of safety policies played a vital role in improving their safety outcomes. Therefore, this thesis proposes that on-site safety supervision and management (Chapter 5) should be strengthened to

improve compliance with safety policies among both managers and CMCWs. Safety incentive strategies (Chapter 4) can also be implemented to enhance safety compliance among CMCWs.

6.2.2.2. Cultural Factors (meso-level)

Cultural factors can be categorised as language barriers and cultural differences. Language barriers are invariably regarded as the dominant influencing factor affecting the health and safety of migrant construction workers. The impact of language barriers on migrant construction workers is multifaceted.

Language barriers can significantly hinder effective communication between migrant construction workers and their supervisors or native workers. Communication barriers can further impact the health and safety of migrant construction workers by decreasing their work efficiency, extending their working hours, and increasing repeated work. Based on the research findings in Chapter 5, all study participants acknowledged that the language barrier is the most influential factor affecting their health and safety. However, the p-value between communication barriers and safety outcomes for CMCWs in Chapter 3 was 0.822, which is greater than 0.1. This means that communication barriers showed an insignificant influence on safety outcomes for CMCWs. This research result, challenging conventional outcome, indicates that the impact of language barriers on the health and safety of CMCWs was not reflected in communication. Moreover, the p-value between cultural differences and safety outcomes in Chapter 3 was 0.319, which also did not show a statistically significant influence.

In response to this phenomenon, a reasonable explanation was proposed based on the questionnaire results in Chapter 3 and the semi-structured interview results in Chapter 5. Most CMCWs worked for overseas Chinese construction companies or construction workplaces with Chinese leaders, which decreased the impact of language barriers on communication. This explanation has been corroborated by other studies. For instance, bilingual managers or workers can mitigate communication barriers among migrant construction workers of different languages on the construction site and can even

eliminate some safety hazards (Fellows et al., 2023, Oswald et al., 2019, Vignoli et al., 2021). The strong in-group identification among Chinese migrant workers and diasporic transnationals can effectively decrease communication barriers and cultural differences within homogeneous Chinese groups.

According to the research results presented in Chapter 5, the impact of language barriers on the health and safety of CMCWs is mainly manifested in two aspects: obtaining safety information and comprehending local safety regulations. It can be challenging for migrant construction workers to independently access compensation information due to language barriers, and the acquired information may also contain misunderstandings or disinformation. The CMCWs in the semi-structured interview surveys demonstrated that while they believed in the existence of safety regulations on the local official websites, they lacked knowledge on how to access those regulations and struggled to understand the English version of safety regulations, especially for CMCWs with limited English proficiency.

6.2.2.3. Personal Factors (micro-level)

Personal factors such as lack of safety awareness, irregular safety behaviour, and limited education level are all influencing factors that endanger the health and safety of CMCWs. The weak safety awareness of migrant construction workers can lead to their resistance to wearing PPE as they insist that this protection will hinder their work efficiency. According to the results of the PLS-SEM analysis given in Chapter 3, the p-value between personal variables and safety outcomes is 0.042 (less than 0.05), and thus shows a statistically significant influence. This research finding demonstrates that standardizing personal variables such as safety awareness can effectively improve the safety outcomes for CMCWs. Hence, the research in Chapter 5 focused on strategies to improve the safety awareness of CMCWs.

Safety training can effectively improve the personal factors (safety awareness) of CMCWs. For instance, safety training has the potential to reduce the unsafe behaviour rate of Chinese construction workers by over 60%. However, the inter-relationship between safety training and safety outcomes for CMCWs was not significant as the p-value was 0.151, which is greater than 0.10. This result can be attributed to the influence of personal factors among CMCWs on their safety training perception. On the one hand, Chinese construction workers tend to be reluctant to attend safety training due to their older working age and lower education level. On the other hand, PRC's construction technology has consistently impressed engineers around the world (Machine Eye, 2016).

Most CMCWs possessed specific construction skills before migrating to the host country, leading to reluctance to retake local training courses, especially safety training courses. Migrant construction workers may exhibit overconfidence. This overconfidence is a sign of poor safety awareness, and this point was verified in the safety training tests in Chapter 5, where CMCWs were required to participate in two safety training tests to assess their safety knowledge levels before and after safety training. Although all CMCWs demonstrated that they had finished the local safety training courses, the average correct rate in the safety pre-test is only 38.96%. Only 1 out of 22 CMCWs correctly answered all test questions before safety training.

6.2.3. Targeted Initiatives for improving the health and safety of CMCWs

Based on the research results presented in Chapters 2 and 3, safety policies and personal variables (like safety awareness and safety behaviour) are the most significant influencing factors affecting the health and safety of CMCWs. Hence, this research aims to enhance the overall safety level of CMCWs by utilising a safety platform to address these two influencing factors.

This thesis established a novel safety web prototype to explore the effectiveness of a safety platform that can improve the health and safety of CMCWs. Various studies have proved that building prototypes can be a feasible strategy for conducting in-depth explorations of research objectives (Bradbury et al., 2014, Bradbury et al., 2018, Yardley et al., 2015). Based on the semi-structed interview surveys (Chapter 5), there were four sections in this safety web prototype: (1) Health and safety policy, (2) Safety training, and (3) On-site safety management, (4) Safety incentives. The final version of web prototype is shown in the Appendix 5.

The interview results show that most respondents (73%) acknowledged that this web prototype can effectively improve the health and safety of CMCWs, especially in terms of accessing local safety policies/regulations and fostering safety awareness. Respondents conveyed that the construction industry in some countries, such as NZ, faced a deficiency in the practical application of a Chinese version of available safety management platforms. The bilingual version of the web prototype not only addressed this gap but also enhanced the participation of CMCWs. Both Chinese and English versions of this web prototype can further decrease the impact of language barriers on CMCWs in host countries. Within the health and safety policy section of this web prototype, all CMCWs in NZ can access local safety regulations and the Chinese version of the on-site safety manuals. Hence, this section was recognized as efficient in elevating the health and safety level of CMCWs.

Moreover, the safety training section of this web prototype also proved to be effective in improving safety awareness and knowledge among CMCWs. The outcomes of the safety training test (Chapter 5) indicate that CMCWs have extremely strong learning and training transfer abilities. Training transfer ability refers to a trainee's capacity to apply the knowledge acquired from safety training courses to actual engineering scenarios. After experiencing safety training, the overall average accuracy rate

increased significantly to 87.01%, marking an approximate 48% increase. The proportion of CMCWs who answered all test questions correctly also rose from 5% to 46%.

While, in Chapter 5, some respondents questioned the autonomy and motivation of CMCWs to participate in the safety platform, this web prototype addressed these apprehensions through the safety incentive section. The research findings from Chapter 3 elaborated on the effectiveness of incentive strategies in motivating construction workers through a systematic literature review. This research result is also applicable to CMCWs. According to these research findings, safety incentive strategies can be divided into positive safety incentives and negative safety incentives. Negative safety incentives (such as oral or written reprimand, fines, suspension from work, and so forth) are frequently employed by site managers to regulate the safety awareness of CMCWs.

However, this thesis recommends adopting positive safety incentives to motivate CMCWs on the construction sites. The primary objective of Chinese migrant workers employed overseas is to obtain higher financial benefits. Hence, safety incentives, particularly financial incentives, can play a vital role in boosting the motivation and safety compliance of CMCWs. Some researchers have illustrated that financial incentives may affect the effectiveness of safety incentives by raising the risk that construction workers conceal incidents or injuries to receive financial rewards (Kim et al., 2019, Gangwar and Goodrum, 2005, Zhang et al., 2022). Therefore, this thesis proposes small-scale, multiple-time financial and non-financial safety incentives to motivate CMCWs to visit this safety web prototype.

6.3. Contribution

The research findings of this thesis have significant contributions and implications for researchers, CMCWs, and the NZCI. Firstly, this thesis is conducive to researchers' future research in the health

and safety field for CMCWs. The research results not only narrow the academic gap in this field but also provide valuable data and a theoretical model (PLS-SEM model) to support academic exploration for other researchers. Secondly, this thesis provides a comprehensive definition of CMCWs, which is broadly applicable to all overseas Chinese migrant workers. This definition aids in the data classification and statistical analysis of Chinese migrant workers across different countries. Additionally, it can be extended to various industrial sectors, thereby contributing to the improvement of health and safety standards for Chinese migrant workers in different industries.

Thirdly, this thesis develops a novel safety web prototype designed specifically for Chinese migrant workers in the NZCI. This web prototype serves as a management tool to address various factors that endanger the health and safety of CMCWs, including limited knowledge of local safety policies/legal rights, personal variable issues (insufficient safety awareness, education, and compliance), language barriers, the lack of long-term and frequent safety training, and the absence of safety incentives. The research findings demonstrate that Chinese migrant workers are a vital labour resource in the NZCI. Consequently, enhancing the health and safety of CMCWs contributes to elevating the overall safety standards of the NZCI. Furthermore, the prototype developed in this thesis can be adapted for use by migrant workers of different nationalities and in other industries, thereby increasing New Zealand's competitiveness in the international labour market. This, in turn, could help address the current skills shortage in NZ. The specific contributions are explained in detail below.

6.3.1. Narrow the research gap

With the development of globalization, CMCWs have gradually become one of the main labour resources in the international labour force markets. However, there is still a lack of academic literature on the health and safety of CMCWs. This thesis used qualitative and quantitative research methods to conduct an in-depth exploration of the literature gaps in the following four research areas:

1) Influencing factors affecting the health and safety of CMCWs,
2) Inter-relationship between influencing factors and safety outcomes for CMCWs,
3) The impact and effect of incentive strategies on the safety performance of CMCWs, and
4) The effectiveness of safety platforms for the health and safety improvement of Chinese migrant workers in the construction industry.

This thesis undertook a thorough and systematic analysis of the health and safety issues of CMCWs through 6 chapters, offering a theoretical foundation and literature support to contribute to research in the construction safety management field.

6.3.2. Unified standardised definition

This thesis proposes a standardised definition for CMCWs. A standardised definition will significantly contribute to long-term theoretical and practical research progress in the research field (Gong and Ribiere, 2021). A unified definition could facilitate the necessary protections and support for migrant workers in the construction industry through the safety policies and programmes of the government or organizations (Hannigan et al., 2016). This means that policymakers and safety managers could devise precise and effective solutions that address the unique demands or challenges faced by migrant workers (Anderson and Blinder, 2011). Furthermore, diverse definitions have a detrimental influence on the statistical and categorization of migrant workers by governments and researchers. For example, different governments or researchers who are involved in collecting, collating, or researching the data will have different opinions on the definition of migrant workers, thus reducing the usability and validity of the research findings of the data screening (Dong and Platner, 2004). This standardised definition has a vital benefit for further research and statistics on the health and safety of CMCWs. The proposed definition will also facilitate the effectiveness of research and bridge existing research gaps on the health and safety of all migrant workers in the construction industry.

6.3.3. Contribution for practical application

This thesis establishes a novel PLS-SEM model for exploring the internal relationship between influencing factors and safety outcomes among CMCWs in the NZCI, as well as developing an innovative web prototype for a safety platform tailored to the health and safety improvement strategy. This PLS-SEM model provides a robust structural framework for research in the field of health and safety concerning CMCWs. The model effectively explains the complexities surrounding the health and safety of Chinese migrant workers within the construction industry. The creation of this web prototype contributes to the design and evaluation of the existing technological web-based safety management platform. This research utilized this web prototype as a model to explore the generalisable conclusions of the effectiveness of web-based safety management platforms in enhancing the safety of migrant construction workers. This means that the NZCI can develop and apply this prototype to enhance the safety standards of migrant workers across various industries. As safety levels improve across different industries, more skilled workers will be attracted to New Zealand, thereby making a significant contribution to the development of NZ.

Both the PLS-SEM model and the web prototype provide a foundation for future extensive research. These models were constructed based on feedback data from CMCWs in NZ. The significant analysis results derived from PLS-SEM model and the web prototype have been shared with a market & research advisor in Sitesafe. These research results can aid NZ government and construction associations in comprehending and addressing the demands and challenges of migrant construction workers for on-site safety management. This understanding will enable the development of effective safety management measures to improve the health and safety of migrant construction workers.

6.4. Limitations

While this study explores the influencing factors of the health and safety of CMCWs and proposed solution strategies, it is essential to acknowledge certain limitations inherent in the comprehensive

overall research process. This section illustrates the limitations of this thesis and proposes improvement measures for future studies.

The empirical data collection is limited to the NZCI. The research sample is the CMCWs in NZ only, which results in a lack a sample data. For instance, the research findings from the data collection detailed in Chapter 4 indicate that only 156 respondents participated in the questionnaire survey, with 120 valid questionnaires for analysis. The lack of sample data may potentially impact on the conclusions drawn from quantitative studies. Hence, future research needs to further expand the sample groups. For example, similar to NZ, there are a large number of CMCWs in the UK and Australia. Subsequent research can use the same PLS-SEM model to investigate the factors influencing and potential safety enhancement solutions for Chinese migrant workers within the construction industry in the UK and Australia.

In addition, bias issues may exist for both researchers and respondents. For instance, within the systematic literature review presented in Chapters 2 and 3, there is a potential risk of bias in the article selection process. This study mitigated the bias impact on literature screening by establishing standardised screening criteria and joint screening by multiple researchers. Respondents may also be biased in the questionnaire survey (Chapter 4) and semi-structured interview survey (Chapter 5). However, meticulous strategies were implemented to ensure validity and reliability in these chapters. For instance, all the questions in the questionnaire survey and semi-structured interviews were peer-reviewed and a pilot test was conducted before the formal test.

6.5. Future Research

As a result, future research can utilise all the research findings in this thesis as a basis to investigate overarching conclusions regarding the health and safety challenges of CMCWs in various countries.

Eventually, researchers can draw the general rules of the health and safety challenges encountered by migrant workers of diverse nationalities within the construction industry.

In addition, researchers will continue to refine the web prototype. For instance, VR technology could be integrated into the safety training function, and site supervision and management could be enhanced through a real-time monitoring system. Advancing the prototype will require both technical and financial support from the NZCI and government.

The effective implementation of safety incentives is also an important research direction for improving the health and safety of CMCWs. This thesis found that the effectiveness of incentives in actual projects depends on the decisions made by construction company managers or clients regarding site safety management. These decisions are influenced by factors such as the project's size, cost, duration, and the extent of government intervention. Based on the systematic literature review in this study, future research should establish a novel theoretical model to explore the factors influencing the effectiveness of safety incentives for CMCWs and their overall significance.

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Appendices

Appendix 1. Summary of study characteristics in 68 identified articles.

Study	Existing Incentive strategies	Analysis of the effectiveness of incentives in the article
(Kidd et al., 2004)	Although the incentive mentioned in the article is a financial incentive provided by workers' compensation insurers to companies that participated in the intervention, respondents demonstrated that cash or a gift certificate might well have been more meaningful to them than an insurance discount for the company.	The effectiveness of incentive strategies depends on the characteristics of the target group, or the degree of inconvenience associated with participation.
(Ai Lin Teo et al., 2005)	Positive incentives: • Monetary reward/bonus • Job promotion (position) • Certificate of recognition • Rewards in kind (overseas trips, dining and shopping vouchers) • Personal recognition (safety employee of the month award) Negative incentives: • Close and strict supervision Extinction: • Termination of service • Reporting to authorities Punishments: • Imposing fines • Suspension from work Demotion (position)	The results show that all five positive reinforcements (monetary and non-monetary) were found to be effective in promoting safe work practices, but monetary rewards were the most effective. Generally, positive reinforcement has been found to be more effective in motivating workers to perform desired behaviours and increasing their job satisfaction, while punishment can be effective in stopping undesired behaviours but can also lead to negative outcomes such as decreased motivation and job satisfaction, as well as increased resentment and counterproductive behaviours.
(Gangwar and	Safety incentive programs can be divided into injury/illness-based	Injury- and illness-based incentive schemes raises the risk of workers

Goodrum, 2005)	incentive programs and behaviour-based incentive programs. Injury- and illness-based incentive programs reward workers based on the number of injuries and or illnesses free days. Behaviour-based incentive programs reward workers based on workers' behaviour.	intentionally eliminating injury reports to obtain incentives. Although behaviour-based incentive programs eliminate the problem of insufficient injury reports, it becomes complicated and difficult to measure in the implementation process. Incentives have a positive impact on safety performance, but the impact will decrease over time.
(Teo et al., 2005)	There are several aspects related to incentives, including the introduction of incentives, level, and type of incentives in terms of bonus, level and type of incentives in terms of promotion, level and type of incentives in terms of certificate of recognition, level and type of incentives in terms of rewards in kind, and level and type of incentives in terms of employee of the month award. Negative incentives include fines (monetary), suspension from work, reporting to relevant authorities, demotion (position), and termination of service.	The study found that incentives were effective in promoting safety and motivating workers to comply with safety rules and regulations. The article also suggests that the most effective incentive programs on encouraging team spirit and individual recognition, and that non-monetary incentives such as personal recognition and promotion through ranks can be just as effective as monetary incentives. The implementation of monetary fines is mentioned as a measure to deter safety violations, but it is not considered desirable as the primary objective of the incentive/disincentive system is to promote safety and not to lower workers' morale. Disciplinary actions should be the last resort and reserved for serious safety and health offenses or repeat offenders.

(Irizarry and Abraham, 2006)	Disciplinary action programs are more common than safety incentive programs in construction sites. Some companies promote safety by penalizing unsafe behaviour rather than rewarding safe behaviour.	This result points to the possible ineffectiveness of safety incentive programs in reducing injuries among workers in steel erection.
(Aksorn and Hadikusumo, 2008)	No specific incentive strategies	Incentive schemes are one of the most effective ways to eliminate accidents and injuries by providing rewards to increase safety awareness, enhance safe behaviour and deter unsafe worker behaviour.
(Brown and Barab, 2008)	The incentive strategy used in KFM's Behaviour-Based Safety (BBS) program was to provide financial incentives to workers and supervisors who did not report injuries, while using reprisals and threats of reprisals against those employees who did report injuries.	This strategy suppresses reporting of injuries and illnesses on site, which ultimately led to numerous injuries and illnesses.
(Hassanein and Hanna, 2008)	Companies should award financial or non-financial rewards to increase safety performance.	One study illustrated that safety incentives were associated with safer performance.
(Idoro, 2008)	Incentives include safety bonus, safety award, safety gift and promotion.	Nigerian contractors rarely provide safety incentives to workers, which limits the expected impact of safety performance.
(McDonald et al., 2009)	Safety program to protect workers' safety on construction sites. This program includes PPE, regular toolbox talks, hazard analyses before an accident as well as a first-aid process after a worker is injured.	The incentives were effective in promoting good safety performance. The injury-reporting policy, along with the incentives, contributed to building a true commitment to safety

		instead of encouraging under-reporting to get incentives.
(Molenaar et al., 2009)	Performance feedback or the traditional financial incentives (money and merchandise) can be used as safety incentives. Disincentive is a form of punishment including oral reprimand, written reprimand, garnishment of wages, and termination of employment.	Safety incentives have been proven to increase safety performance. Safety incentives influence safety performance more than disincentives.
(Teo and Ling, 2009)	Incentivise workers with bonus (monetary), promotion (position), certificate, rewards (trip overseas, dinning & shopping vouchers, etc), and personnel recognition. Penalties include fines (monetary), suspension from work, demotion (position- only applicable to supervisors), lay-off, and reported to relevant authorities.	Compared with punishments, incentives could be more effective for enhancing workers' safety performance. The effectiveness of incentive programs is dependent on the type of incentives and the way of incentive are allocated. Money rewards are difficult to implement in practice and cannot ensure efficacy. The most successful incentive programs include encouraging team spirit and individual recognition.
(Chan et al., 2010)	Using Pay for Safety Scheme (PFSS) to award workers with financial incentives like bonus, prize, gift, or coupon.	PFSS can successfully lower construction site safety incidents in addition to bringing about desired safety performance.
(Mohammad et al., 2010)	Increasing fines to workers with poor safety performance.	The top five high-impact zero accident strategies include safety incentives.
(Pires, 2011)	Increase the public budget and reward workers who meet the safety targets by bonuses or more salaries.	This creates an incentive for workers to be more efficient and effective.

(Hu et al., 2012)	If the general construction contractor could meet all these conditions, it would receive the commendation certificate and a bonus, which is approximately 0.1–0.3% of the contract price, over and above the original competitive bid price.	Economic incentives for contractors can improve site safety standards and reduce the risk of injury to construction workers.
(Ma et al., 2012)	The contractual incentive strategies could include monetised incentives, contractual incentives for cost reduction, and the prioritisation of time, cost, and scope over quality.	The contractual incentives could provide negative influence for various involved parties which lead them to make decisions where safety is sacrificed to the benefit of other values.
(Ajslev et al., 2013)	Compared with monetary fines, incentives like bonuses, personal recognition, promotion, and attendance at reward functions may also be effective for protecting workers' safety on construction sites.	Incentives are more effective in influencing construction employees' safety performance than punishment. Economic and non-economic incentives both have the same result.
(Hasan and Jha, 2013)	Safety incentive and penalty (I/P) should be awarded all workers if no one get injuries in a particular period. Manager/safety directors should incentivise workers at dinner/toolbox meetings. The award form could be bonus (monetary), promotion (non-monetary), and penalty for unsafe work.	Project with Safety incentive and penalty (I/P) has better safety performance than those without I/P. Currently, punishment measures often taken in engineering projects, which result in poor safety performance of both contractors and workers. To increase overall project safety performance, I/P planning must include clients, contractors, and employees.
(Lipscomb et al., 2013)	The implementation of safety incentive programs, which pay workers cash, gifts, or other benefits	The article concludes that the effectiveness of safety programs depends on the context in which they

	for avoiding injuries is advised for construction businesses in this article. Moreover, the programs gave prizes or benefits to work groups or workers who reported fewer injuries. The penalty discussed in this article also includes fines for employees who fail to submit all injury data, penalties for workers who abuse drugs or alcohol, and disciplinary action for those who take ‘‘too many’’ days away from work.	operate, and a more comprehensive assessment of job site risks and management practices is needed.
(Shin et al., 2014)	The incentive strategy described in the text is providing an additional financial incentive to workers who exhibit safe behaviours. The specific value for the incentive is determined to be 30% of the worker's basic payment, but this value can vary depending on the company's safety policy.	The simulation results suggest that providing incentives for safe behaviour earlier in the construction project is more effective than providing them later.
(Zulkefli et al., 2014)	Incentives include recognition, time off, stock ownership, special assignments, advancement, increased autonomy, training and education, social gatherings, prizes, and money.	Incentives are the most effective way for top managers to allocate workers according to the two categories of maximum and best contributors to improve the safety performance of workers. Compared with monetary incentives, non-monetary incentives have been found to be more effective in reward and recognition.
(Ghasemi et al., 2015)	Financial incentives include cash or gift reward.	Incentive is one of the six management practices that can

	Non-financial incentives include flashes, home appliances, pilgrimage, praise through newspapers.	proactively reduce the injury rate in industries. However, the incentive system will not necessarily lead to the improvement of safety performance. For workers with strong religious beliefs, managers should pay more attention to respecting workers' religion when implementing incentives
(Guo et al., 2015)	The incentive programs mentioned in the text are designed to motivate construction companies to improve their safety performance by offering them discounts on ACC work cover levies.	The effectiveness of incentive programs may be effective in the short term, but they can have long-term side effects.
(Sparer et al., 2015)	This article proposed another safety incentive program based on a leading indicator like hazard recognition to incentive workers. If the workers achieve the score in leading-indicator-based incentive programs, all workers will be rewarded by lunch, public recognition, and parking spot raffle.	The new safety incentive program not only improved workers' acceptance of safety performance but also eliminated the drawbacks of traditional methods such as concealing accidents or injuries.
(Teran et al., 2015)	Several incentives are mentioned in the article, including enforcement through fines and citations, economic incentives such as discounts on workers' compensation premiums or rebates.	These incentives could be effective in promoting the adoption of fall protection measures in residential construction.
(Fernando Alarcon et al., 2016)	No specific incentive strategies	Safety incentives can effectively improve workers' safety performance in the short term but are counterproductive in the long-term.

(Lengagne, 2016)	This article proposes an experience rating (ER) in the workers' compensation system to improve work-related health and safety outcomes.	The article notes that there may be unintended consequences of ER policies, such as underreporting or worker selection, which could potentially act as punishments for firms that do not comply with health and safety regulations.
(Zahoor et al., 2016)	The passage mentions several incentives that can be used to improve occupational safety compliance.	The effectiveness of these incentives in improving occupational safety compliance varies depending on the context and the specific incentive used.
(Jide et al., 2017)	The study suggests that reducing training costs, providing financial awards for workers, and increasing wages after completing the course can all serve as effective incentives to encourage attendance.	The effectiveness of the incentive depends on how well it can motivate both employers and workers to invest in training.
(Man et al., 2017)	The incentives mentioned is the use of safety fines and safety incentives to establish a level of performance where construction workers cannot make money by taking risks, while they can gain monetary incentives by working safely.	The effectiveness of this incentive is suggested to be that it can reduce construction worker risk-taking behaviours encouraged by the desire to make more money under the multi-tier subcontracting system.
(Zahoor et al., 2017)	There are several incentives for improving safety performance in the construction industry in Pakistan, including safety awareness campaigns, adequate safety training, and safety incentives.	The effectiveness of these incentives is not explicitly stated, but it is implied that they could help enhance safety compliance and reduce the occurrence of accidents.

(Gao et al., 2018)	Incentive strategies include bonuses, certificates of recognition, gift rewards, employee of the month awards, and promotions. Punishment (disincentive) include fines, suspension from work, reporting to relevant authorities, demotion, and termination of contracts.	Although incentives can improve workers ' safety performance, this method has obvious drawbacks, especially when using financial incentives. The impact of incentives is obscured when rewards are excessively simple to attain or substantial. Punishment measures are essential for safety management. The implementation of restraining measures aids in regulating employees' safety-related conduct.
(Guo et al., 2018)	There are three incentive strategies could be used in BBS program, which are the dynamics of goal commitment, punishment, and financial incentive.	The workers' sense of achievement will decline as they meet a safety objective, resulting in a decrease in their motivation to continue safe behaviour. The dynamics of goal commitment will become a continuous driving force for workers to maintain safe behaviour. Punishment can be an effective motivator in the short term. The third incentive strategy is the use of monetary incentives. While monetary incentives can be an effective motivator, they can also create unintended negative consequences.
(Li et al., 2018)	Increase workers' safety performance by basic performance income or excessive performance rewards like bonuses, penalties, awards, and advancement.	The distribution of excessive performance rewards is better than the distribution of basic performance income if workers' safety behaviour

		level is related to the level of safety perception of workers. The variance of basic performance income will influence on workers' safety performance when the fair perception existing between team members.
(McDermott et al., 2018)	The long-term incentives are used to motivate only senior management like CEO or managing directors by financial indicators like shares. The short-term incentives are linked workers' performance with safety indicators such as productivity, workplace safety, financial performance, and client/customer satisfaction.	Despite a strong safety commitment, there is still a poor alignment between long-term safety performance and long-term safety incentive plan.
(Kim et al., 2019)	Workers will receive financial rewards once employees meet or surpass a company-mandated safety threshold at the end of the reward period (a month or a quarter).	Safety incentives which interact with safety management systems significantly improve safety performance. One of the most effective safety measures is written incentives. However, incentives may result in workers not reporting injuries in order to be rewarded.
(Lingard et al., 2019)	The passage describes how public sector clients in infrastructure projects have incorporated financial penalties for poor occupational health and safety (OHS) performance into project contracts.	The article argues that these negative incentives do not promote positive performance and collaboration in relation to OHS.

(Abas et al., 2020)	The incentives can take many forms, such as cash bonuses, gift cards, or recognition programs. Moreover, non-financial incentives include the "Best Construction Site Award" and the "Best Employee Award." Furthermore, a reward system for reporting unsafe workforce behaviours could also motivate workers to repeat safety behaviours.	The effectiveness of incentives in safety incentive programs has been shown in various studies to have a positive impact on safety performance. It may be effective in promoting a culture of safety and encouraging workers to prioritise safety in their work practices.
(Campo et al., 2020)	Economic incentives to companies	Incentives can improve safety compliance.
(Han et al., 2020)	Incentive strategies include verbal or certificate-based safety awards and cash incentive.	Safety incentives are identified as the most important contributor to overall safety performance. However, clients should not invest too much in safety incentives. In the contractor 's view, multiple small safety awards are more effective in improving the safety performance of workers.
(Hosseinian et al., 2020)	This article proposed an incentive scheme (results sharing contract), which is the more workers contribute to the project, the higher their share of outcomes, but the lower their effort cost, the more they are likely to share outcomes.	The effectiveness of this incentive is that it aligns the interests of the owner with those of the contractor and motivates the contractor to put effort in the best interests of the owner, thereby reducing contractor opportunistic behaviour.
(Mohammadi and Tavakolan, 2020)	Several types of incentives are mentioned in the text, including awards for excellent safety performance, verbal praise or public recognition, and penalties for unsafe acts or conditions.	Incentive strategies are conducive to encouraging workers to repeat safety behaviours. Both punishment and incentive effectively promote safety performance. However, the effect of incentives will diminish over time.

(Ahmed and Kabir, 2021)	There are several incentives mentioned in the text for promoting compliance with building codes and regulations: • Monetary penalties for non-compliance by engineers and building owners. • Not providing building permits unless proper building codes are followed. Financial incentives and certificates of recognition to small-scale contractors and workers for compliance.	Incentives can be effective in promoting compliance with building codes and regulations, but these strategies need to be part of a broader strategy that includes education, awareness raising, monitoring, and enforcement.
(Guo et al., 2021)	The incentives can include rewards such as financial incentives or subsidies for construction units that provide safety education, and welfare subsidies for construction workers who actively participate in safety education. On the other hand, punishment can include penalties or fines for construction units that fail to provide safety education, and possibly even legal consequences for serious safety violations.	This incentive mechanism could encourage construction units to provide safety education and construction workers to actively participate in safety education.
(Ji et al., 2021)	The tournament incentive system involves paying higher salaries to individuals or teams with higher rankings based on their performance.	The effectiveness of this incentive depends on various factors, including the fairness preference heterogeneity, risk attitude, and abilities of workers. It is feasible that this incentive could be effective in promoting safety

		behaviour among construction workers.
(Onubi et al., 2021)	Safety performance could be motivated by monetary incentives.	Improvements in financial performance are driven by economic incentives, which will ultimately contribute to improvements in safety performance.
(Zhu and Cheung, 2021)	In this article, the concept of construction incentivization (CI) is introduced as a process of motivating providers to achieve extra value-added services in construction projects. The most commonly used CI is financial rewards for meeting cost, schedule, quality, and safety targets. The least used CI is nonfinancial incentives, such as better conditions compared with the original contractual terms, including earlier payments.	While safety incentive schemes have been effective in improving project quality metrics in some countries, many projects with CI have also experienced serious delays, cost overruns, and disputes.
(Afuye et al., 2022)	Incentives used by contractors could be divided to four directions: positive reinforcement, negative reinforcement, punishment reinforcement, and extinction reinforcement. Positive reinforcement includes praise, monetary rewards, non-financial reward (free lunch, extra vacation, and promotions). Negative reinforcement includes criticism or the threat of losing a job.	Monetary or non-monetary incentives (reinforcement) play vial roles in encouraging good safety performance in workers. The safety behaviour reward system in the construction industry in southwestern Nigeria is poorly implemented. The most used incentive measures for large and medium-sized enterprises are strict supervision and management. In medium-sized enterprises, the rating of fines for unsafe behaviour is the lowest. Large enterprises do not give

	Punishment reinforcement includes pay cuts, temporary suspensions, demotions, and firing. Extinction reinforcement includes appointment terminated.	priority to feedback on workers ' safety performance, while medium-sized enterprises do not pay much attention to incentives (reinforcement).
(Egbelakin et al., 2022)	The incentive identified in the study is the provision of monetary incentives, such as reduced insurance premiums and financial subsidies.	The findings suggest that monetary incentives alone may not be sufficient to encourage adoption due to the perceived high cost of implementation.
(Gray and Mendeloff, 2022)	The incentive strategy in this article is to inspect workplaces to find infractions and punish such offences financially.	The potential penalties provide incentives for employers to reduce the workplace hazards covered by OSHA standards, with the size of the incentive depending on the frequency of inspections and the size of the penalties.
(Huang et al., 2022)	Positive incentives: A certain degree of economic reward for workers with high safety compliance Negative incentives: A punishment for workers who violate the regulations	High positive incentives are the driving force for increasing workers' safety performance and high negative incentives are the binding force for workers' safety behaviour. However, safety management may fall into a chaotic state if these two incentive strategies become extreme.
(Liu et al., 2022a)	The research findings indicate that only when the safety punishment imposed on construction workers is large enough will the supervision behaviour of local governments and construction enterprises encourage construction workers to choose not to violate the regulation.	A strict and effective punishment system is necessary to prevent violations and improve construction safety.

(Liu et al., 2022b)	The article discusses the use of incentive mechanisms, such as reward and punishment, and income sharing, to encourage construction workers to adopt safe behaviours and improve the level of construction safety	This mechanism can improve the safety level and income of both the construction enterprise and construction workers.
(Ninan et al., 2022)	Financial and non-financial incentives are mentioned in the text as factors promoting innovation in the building sector. Financial incentives include profit maximization, reducing construction costs, saving worker workdays lost due to accidents, and avoiding penalties for safety incidents. Non-financial incentives include enhancing the firm's image and reputation.	The effectiveness of financial incentives is highlighted in the passage as being more effective in driving innovation in productivity and health and safety, while non-financial incentives are more effective in driving innovation in sustainability.
(Ning et al., 2022)	This article proposes two mechanisms, the third-party participation mechanism and the enterprise entity responsibility mechanism. The implementation of the two mechanisms is affected by punishment, subsidy, and cost.	The government's incentives to introduce these mechanisms include improving the efficiency of government supervision, promoting ordinary government supervision, and accomplishing intended regulatory purposes with fewer resources. The study highlights the importance of incentives in promoting the implementation of effective regulatory mechanisms in the construction industry.
(Peng and Zhang, 2022)	Authors suggest using a tough monetary punishment to improve workers' safety performance.	This article suggests that traditional punitive measures, such as fines and reprimands, may not always be

		effective in inducing a change in worker behaviour. It is important to note that the effectiveness of punishment as a tool for promoting safety is a complex issue and depends on various factors, including the severity and consistency of the punishment, the perceptions, and attitudes of the workers towards the punishment, and the overall safety culture within the organization.
(Wu et al., 2022)	This paper mentions three strategies to motivate construction workers to continue safe behaviour, which are punishment, encouragement and financial reward.	The role of fines in restraining unsafe behaviour is limited. The monitoring of construction sites can be improved by raising fines for general contractors, but raising fines for construction employees has little impact on addressing safety issues on construction sites.
(Zhang et al., 2022)	Incentive strategies include rewarding workers who set an example in the team, praising workers' behaviour face to face, establishing a complete incentive system, punishing workers who conceal accidents.	Safety incentives have an indirect, significant and positive impact on workers ' safety performance through safety policies, safety training and safety communication.
(Zhu et al., 2022)	This article recommends incentive and punishment mechanisms to improve construction workers' safety performance.	Construction workers are willing to perform self-motivating safety activities when contractors motivate them by incentive mechanisms. However, the incentive and punishment mechanism will be unstable if the incentive amount is too high.

(Lucas et al., 2023)	Monetary or behaviour-based recognitions	Some companies will use small incentives to motivate workers ' safety performance. Safety incentive programs could motivate good safety performance in the short-term, but not in the long-term.

Appendix 2. Questionnaire survey in Chapter 3.

The link accessing to the questionnaire survey:

https://qfreeaccountssjc1.az1.qualtrics.com/jfe/form/SV_22ZJZxaemkcRqYK

Appendix 2-1 Consent of questionnaire survey

*Project Background

In this research, we will explore the factors affecting the health and safety of migrant construction workers and the internal relationship networks between these factors. Research on the health and safety of migrant workers requires credible data as a basis, which means that it needs to investigate the working styles and personal awareness of migrant construction workers through questionnaire surveys. Such investigations may raise concerns from legal, ethical, and behavioural perspectives. Three objectives will be explored through this project: separately identifying multiple level factors that contribute to poor health and safety outcomes among migrant construction workers, analyzing the relationship between these factors, and enacting strategies for preventing accidents and injuries on construction sites.

Survey Procedure

The questionnaire is structured into two sections: demographic information and health and safety risk factors appraisal. This questionnaire included 40 single-choice questions. Hence, it will take no longer than 20 minutes to complete the survey.

Ethics Notification

This project has been evaluated by peer review and judged to be low risk (with Ethics Notification Number: 400026149). Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director (Research Ethics), email humanethics@massey.ac.nz.

Statement of Consent

This anonymous questionnaire survey that has been designed to ensure that individual participants are not identifiable. To protect your personal privacy, this questionnaire will not count your identity information (such as name, identity card, or telephone number). Your participation is entirely voluntary. You have the right to terminate the questionnaire before or during the survey. By choosing the consent below, you have given consent to participate in this study and to the subsequent reports and publications from this study. All the collected data from this questionnaire will be stored securely in the Massey University data repository and can only be accessed by the relevant researchers.

Researcher:
Zechen Guan, PhD student
School of Built Environment, Massey University
Email: zguan@massey.ac.nz
Phone: +64 2902027314

Supervisors:
Kenneth Yiu, Associate Professor
School of Built Environment, Massey University
Email: t.yiu@massey.ac.nz

Dr Don Samarasinghe
School of Built Environment, Massey University
Email: d.samarasinghe@massey.ac.nz

Dr Ravi Reddy
School of Health Sciences, Massey University
Email: r.reddy@massey.ac.nz

◯ I have read the information above and consent to participate the study

Next page ›

Appendix 2-2 Content of questionnaire survey

Section A. Demographic Information

Please click the right options on the following questions

Age	☐18-29 ☐ 30-39 ☐ 40-49 ☐ 50-59
Gender Identity	☐ Male ☐ Female ☐ Prefer not to answer
Education Level	☐ Primary or below ☐ Secondary ☐ Certificates and diplomas ☐ Bachelor's Degree or higher
What kind of passport do you hold?	☐ New Zealand passport ☐ Chinese Passport ☐ Other Passport
How long have you been working for your company?	☐ ≤ 5 years (less than or equal) ☐ 5-10 years ☐ ≥ 11 years (greater than or equal)
How long have you been in New Zealand?	☐ ≤ 12 months (less than or equal) ☐ 1-5 years ☐ 6-10 years ☐ ≥ 10 years
What kind of visa do you have?	☐ Resident visa or Permanent Resident visa ☐ Work visa ☐ Student visa
What kind of job do you have?	☐ Trade Labour ☐ Site Engineer ☐ Architect ☐ Surveyor ☐ Engineer ☐ Other
What is your current employment arrangement?	☐ Full-time ☐ Part-time ☐ Contractor ☐ Casual/ Day laborer

Section B. What measures do you think are most effective to improve your health and safety at work?

Please circle the number that best describes your response to each statement (from 1 (not important) to 5 (most important)

		Not important	Slightly important	Neutral	Very important	Most important
B1	Enact fair safety policies or regulations	1	2	3	4	5
B2	Regularly on-site safety management such as safety monitor by senior managers or safety conferences	1	2	3	4	5
B3	Provide comprehensive safety training	1	2	3	4	5
B4	Provide high-quality PPE (Personal Protective Equipment)	1	2	3	4	5
B5	Communicate with managers or colleagues effectively and frequently	1	2	3	4	5
B6	Have a safe working environment and safe climate	1	2	3	4	5
B7	Safety incentives or penalties (financial or non-financial)	1	2	3	4	5
B8	Methods to increase workers' safety awareness	1	2	3	4	5
B9	Improve my education and cultural level (like language education courses)	1	2	3	4	5
B10	Methods to alleviate negative emotions (such as working pressure, homesickness, and economic pressure)	1	2	3	4	5

Appendix 2-3

Section C. What do you think about the health and safety risk factor on construction sites?

Please circle the number that best describes your response to each statement (from 1 (strongly disagree) to 5 (strongly disagree)

		Strongly Disagree	Disagree	neutral	Agree	Strongly Agree
C1.	I could fully understand and be confident about the health and safety policies enacted by the government.	1	2	3	4	5
C2.	I think the health and safety policies are not effectively followed.	1	2	3	4	5
C3.	My company has a set of well-established safety policies such as establishing a safety committee and regularly holding safety meetings.	1	2	3	4	5
C4.	My safety training course is long enough for me to master safety knowledge.	1	2	3	4	5
C5.	My safety training has a poor impact because the training model is coursework.	1	2	3	4	5
C6.	I can apply the knowledge of safety training to practical work.	1	2	3	4	5
C7.	I think language barriers are no longer the main factor affecting communication due to the presence of interpreters or multilingual supervisors.	1	2	3	4	5
C8.	I think language barriers are no longer the main factor affecting communication because most of my managers or colleagues are Chinese or Chinese speakers.	1	2	3	4	5
C9.	I know many effective ways to communicate with colleagues and bosses.	1	2	3	4	5
C10.	I can adapt to the culture and work environment of the construction site.	1	2	3	4	5
C11.	I cannot integrate well with other workers because of cultural differences.	1	2	3	4	5
C12.	Some common practices in my hometown are regarded as unsafe behaviours here.	1	2	3	4	5
C13.	I fully understand the hazards and potential risks in the construction sector.	1	2	3	4	5
C14.	Sometimes I must take risks to get the job done.	1	2	3	4	5
C15.	I think the proper incentives (monetary or non-monetary) incentive me to abide by safety standards.	1	2	3	4	5
C16.	I am more prone to physical or psychological problems than local workers.	1	2	3	4	5
C17.	I think education level and language barriers may limit my safety awareness.	1	2	3	4	5
C18.	I do not care about on-site safety because it is my supervisor's responsibility.	1	2	3	4	5

Appendix 2-4

Section D. What do you think about the safety outcomes and safety performance on construction sites?

Please circle the options below that match your request.

	Numbers of near-miss and accident injury in the Last 12 months	Never	Rarely	Some-times	Often	Always
D1.1	How many times were you away from work due to work-related injuries or illness?	1	2	3	4	5
D1.2	How many times have you faced a work-related near miss incident?	1	2	3	4	5
D1.3	How many times have you been injured or sick at work while carrying out your work activities?	1	2	3	4	5
	Safety performance	Never	Rarely	Some-times	Often	Always
D2.1	How often do you engage the safety practices on the construction site?	1	2	3	4	5
D2.2	How often do you check for risk factors in your work environment?	1	2	3	4	5
D2.3	How often do you review the safety behaviour you know about or learn new safety knowledge?	1	2	3	4	5

Appendix 3 Consent Form for the Semi-structured Interview Surveys

Occupational Health and Safety Platform for Chinese migrant workers in the New Zealand construction industry.

Information Sheet

Researchers' Introduction

Zechen Guan (Jack), PhD student, Massey University

Supervisor:

- Dr. Don Amila Sajeevan Samarasinghe,
- Prof Tak Wing Yiu,
- A/Prof Ian Laird, and
- Dr. Ravi Reddy

Project illustration:

On-site safety management always plays a vital role in the construction industry. Existing literature demonstrates that migrant workers are more vulnerable than native workers on construction sites. These harms are caused by the characteristics of both migrant workers and the safety management system. The platform will be presented to respondents in the form of a website. Respondents only need to perform corresponding operations according to the operation manual to complete the test. Respondents can access the website through the laptop or mobile phone. The process of this website is divided into four phases. In the first phase, respondents can check the Health and Safety Act 2015 from this website. In the second phase, Researchers will ask participants to do a quiz to test their safety knowledge on construction sites. There are 6 multiple-choice questions in this quiz and respondents will get one point for each correct answer. After the quiz, respondents can browse safety training cards to learn correct safety knowledge. After the safety training, respondents are asked to do the same quiz again to test whether they handle the safety knowledge. In the third phase, researchers will show respondents how to use this website for on-site safety management. Safety manager could give migrant workers 0 to 14 points based on their safety behaviour on the construction sites. The points earned by respondents will be shown at the final phase. After the test, respondents will be asked to give feedback on this website through a semi-structured interview.

Aim of the project: This project aims to explore whether an Occupational Health and Safety Digital Platform (in the form of a developed website), could enhance the health and safety of Chinese migrant workers in the New Zealand construction industry. This project will ask at least 10 participants to visit this website. Based on their feedback, researchers can validate the effectiveness of this platform

(website) in the safety awareness improvement of CMCWs. In addition to that, this project also can validate whether this website can decrease the influence of language barriers on migrant workers' safety risks and improve their safety awareness and safety knowledge at the same time. This experiment is the last part of my PhD work in Massey University.

Ethics information: *The Ethics Notification Number is 4000027904. This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact the Research Ethics Office, email humanethics@massey.ac.nz.*

Respondents' rights: According to the Code of Ethical Conduct for Research, Teaching & Evaluations involving Human Participants shown on the Massey human ethics website, all the ethical issues in this project have been identified and addressed.

- The confidentiality of participants: The personal information of the respondents, including their names, will be treated with strict confidentiality. None of their personal details will be featured in any published or upcoming articles or videos.
- Respondents' consent: We will inform the participants of the aim of the study and the interview in the Participant Information Sheet (PIS). We will also obtain their written consent to participate before the interview is conducted. The participants are expected to select an available interviewee slot that suits their preferences and availability.
- Disposal of data: According to Massey Ethics Regulations, a clear plan needs to be specified to ensure that data is securely stored and deleted. The respondents will be identified as "interview 1, 2, 3…" based on the sequence of their interviews. Due to this, only the researcher will have access to the interview data. The company leadership cannot know the individual worker's answer and can only be told a simple conclusion. During the semi-structured interviews, all data will be kept by the project supervisor to ensure the security of the information. The data will be permanently deleted by the Ph.D. student after 1 year.

- Right to withdraw: Respondents have the right to withdraw their participation before or during the interviews. In addition, Mandarin can be used to ensure that Chinese migrant workers understand each question and feel comfortable.

PARTICIPANT CONSENT FORM – INDIVIDUAL

I have read the Information Sheet attached. I have had the details of the study explained to me, any questions I had have been answered to my satisfaction, and I understand that I may ask further questions at any time. I am willing to participate in this study and I understand participation is voluntary and that I may withdraw from the study at any time.

I agree to participate in this interview under the conditions set out in the Information Sheet.

I agree to the interview being recorded.

I agree that researchers can use my reply if my personal information is not disclosed.

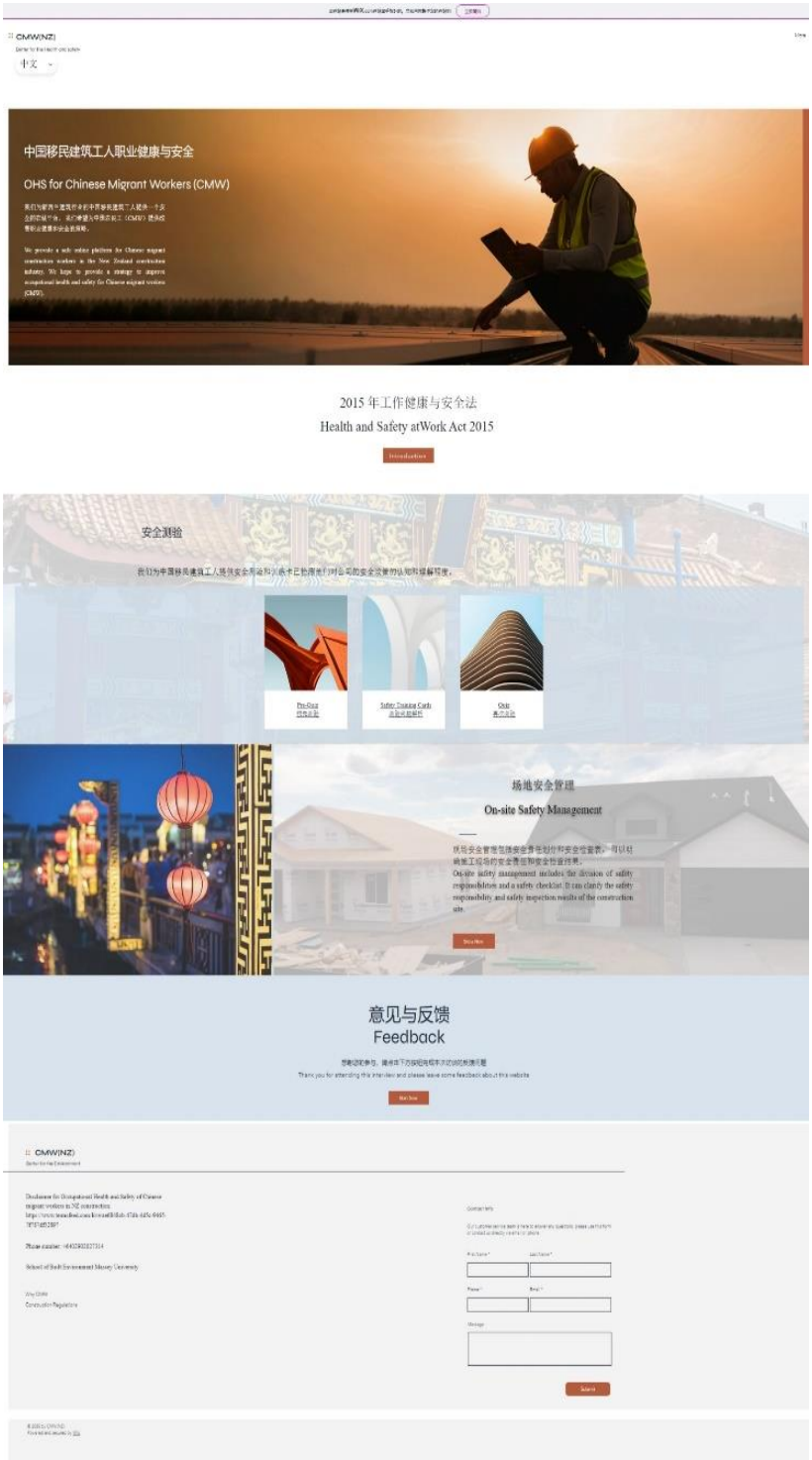
I agree to cooperate with the researchers to complete all tests.

I guarantee that my responses align with my true wishes.

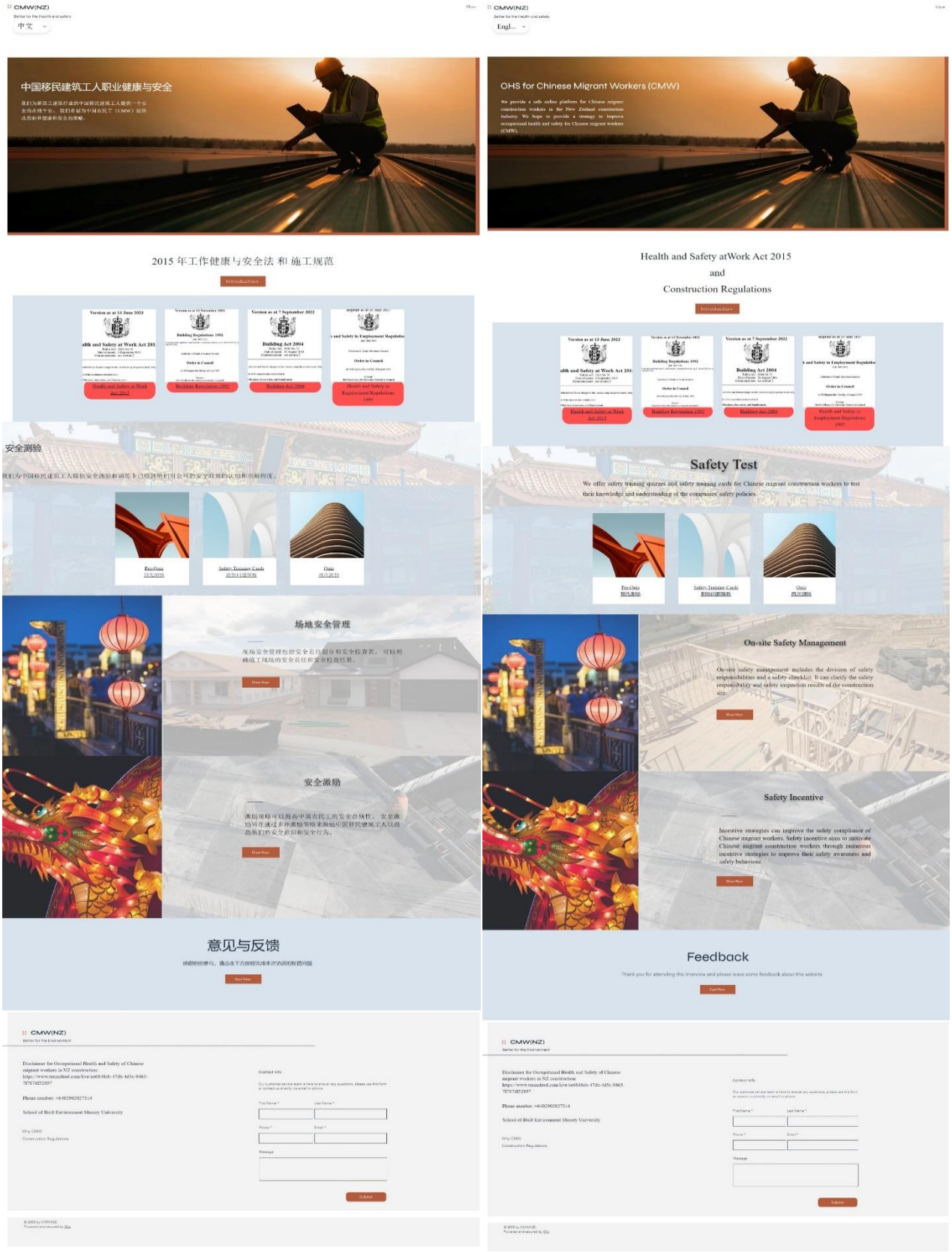
Signature: ..... **Date:** .....

Full Name - printed .....

Appendix 4. Web Prototype Original Version



Appendix 5. Web Prototype Final Version (Left: Chinese version. Right: English version)



Appendix 6. Statement of Contributions

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Zechen Guan
Name/title of Primary Supervisor:	Don Amila Sajeevan Samarasinghe
In which chapter is the manuscript /published work:	Chapter 2

Please select one of the following three options:

(●) The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

Guan, Z., Yiu, T.W., Samarasinghe, D.A.S. and Reddy, R., 2024. Health and safety risk of migrant construction workers – a systematic literature review. Engineering, Construction and Architectural Management, 31(3), pp.1081-1099.

( ) The manuscript is currently under review for publication – please indicate:

- The name of the journal:

- The percentage of the manuscript/published work that was contributed by the candidate:

- Describe the contribution that the candidate has made to the manuscript/published work:

( ) It is intended that the manuscript will be published, but it has not yet been submitted to a journal

Candidate's Signature:	
Date:	04-Apr-2024
Primary Supervisor's Signature:	Don Samarasinghe Digitally signed by Don Samarasinghe DN: cn=Don Samarasinghe, c=NZ, o=Massey University, ou=School of Built Environment, College of Sciences, email=D.Samarasinghe@massey.ac.nz Reason: I am the author of this document Location: Auckland, New Zealand Date: 2024.04.05 13:34:39 +13'00'
Date:	4-Apr-2024

This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis.

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Zechen Guan
Name/title of Primary Supervisor:	Don Amila Sajeevan Samarasinghe
In which chapter is the manuscript /published work:	Chapter 3

Please select one of the following three options:

○ The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

◉ The manuscript is currently under review for publication – please indicate:

- The name of the journal:
ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering

- The percentage of the manuscript/published work that was contributed by the candidate: 90.00

- Describe the contribution that the candidate has made to the manuscript/published work:
Questionnaire surveys, Methodology, data collection, data analysis, writing-original drafr preparation, writing-editing.

○ It is intended that the manuscript will be published, but it has not yet been submitted to a journal

Candidate's Signature:	Zechen Guan
Date:	05-Apr-2024
Primary Supervisor's Signature:	Don Samarasinghe Digitally signed by Don Samarasinghe DN: cn=Don Samarasinghe, c=NZ, o=Massey University, ou=School of Built Environment, College of Sciences, email=D.Samarasinghe@massey.ac.nz Reason: I am the author of this document Location: Auckland, New Zealand Date: 2024.04.05 13:35:13 +13'00'
Date:	5-Apr-2024

This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis.

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TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Zechen Guan
Name/title of Primary Supervisor:	Don Amila Sajeevan Samarasinghe
In which chapter is the manuscript /published work:	Chapter 4

Please select one of the following three options:

○ The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

◉ The manuscript is currently under review for publication – please indicate:

- The name of the journal:
Engineering, Construction and Architectural Management

- The percentage of the manuscript/published work that was contributed by the candidate: 90.00

- Describe the contribution that the candidate has made to the manuscript/published work:
questionnaire surveys, methodology, data collection, data analysis, writing-original drafr preparation, writing-editing.

○ It is intended that the manuscript will be published, but it has not yet been submitted to a journal

Candidate's Signature:	Zechen Guan
Date:	05-Apr-2024
Primary Supervisor's Signature:	Don Samarasinghe Digitally signed by Don Samarasinghe DN: cn=Don Samarasinghe, c=NZ, o=Massey University, ou=School of Built Environment, College of Sciences, email=D.Samarasinghe@massey.ac.nz Reason: I am the author of this document Location: Auckland, New Zealand Date: 2024.04.05 13:35:41 +13'00'
Date:	5-Apr-2024

This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis.

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Zechen Guan
Name/title of Primary Supervisor:	Don Amila Sajeevan Samarasinghe
In which chapter is the manuscript /published work:	Chapter 5

Please select one of the following three options:

○ The manuscript/published work is published or in press

- Please provide the full reference of the Research Output:

◉ The manuscript is currently under review for publication – please indicate:

- The name of the journal:
Safety Science

- The percentage of the manuscript/published work that was contributed by the candidate: 90.00

- Describe the contribution that the candidate has made to the manuscript/published work:
Interview surveys, Methodology, data collection, data analysis, writing-original drafr preparation, writing-editing.

○ It is intended that the manuscript will be published, but it has not yet been submitted to a journal

Candidate's Signature:	
Date:	05-Apr-2024
Primary Supervisor's Signature:	Don Samarasinghe Digitally signed by Don Samarasinghe DN: cn=Don Samarasinghe, c=NZ, o=Massey University, ou=School of Built Environment, College of Sciences, email=D.Samarasinghe@massey.ac.nz Reason: I am the author of this document Location: Auckland, New Zealand Date: 2024.04.05 13:36:06 +13'00'
Date:	5-Apr-2024

This form should appear at the end of each thesis chapter/section/appendix submitted as a manuscript/ publication or collected as an appendix at the end of the thesis.