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보건학 석사학위논문

Factors Associated with Fatal
Occupational Injuries Among
Chinese Migrant Workers in South
Korea

한국 내 중국 이주노동자의 업무상 치명상 위험요인

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이 주 연

Factors Associated with Fatal Occupational Injuries Among Chinese Migrant Workers in South Korea

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Abstract

This study showed migrant workers' occupational safety and health in two chapters. We aimed at two comparison of fatal occupational injury status and characteristics between adult Asian migrant workers and native workers in Asia at the first chapter. Using a systematic review method, four quantitative articles were reviewed. Four electronic data bases were searched for relevant articles in English from inception until April 18 2018. Despite of underreporting incidences of occupational fatal injuries, occupational fatality among migrant workers in Qatar, Republic of Korea, and Singapore had shown statistically significantly higher than those of each native country. Dominant country of origin was different according to the destination of migration, still, commonly most of migrant workers in the articles were male and construction workers, and frequent fatal injury type was fall from height.

In second chapter, we assessed the risk of fatal occupational injuries among migrant workers with two different types of employment permits in South Korea. This observational cross-sectional study used national data from January 2007 to September 2018 and analyzed 42,089 cases of occupationally injured migrant workers of Chinese nationality. Fatality rates were analyzed according to year, sex, age, occupation, industry, and type of employment permit. Chinese workers were permitted to work for one employer and prohibited from changing employers, whereas Korean-Chinese workers were permitted to change their employer. The adjusted fatality rate of occupational injuries of Chinese migrant workers was significantly higher (1.22-fold, 95% confidence interval 1.01-1.47) than that of Korean-Chinese migrant workers. The

prohibition on changing workplaces; male gender; age ≥ 45 years; machine operator; construction industry; and agriculture, livestock, and fisheries industry were risk factors for fatal occupational injuries. The results suggest a need for revision of the migrant worker recruitment systems and implementation of occupational safety and health policies for all workers to promote health equity.

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Keywords : Migrant worker, Risk factor, Workplace change, Occupational injury, Fatality, Occupational Safety and Health
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Introduction

The number of world migrants is 257.7 million as of 2017 (UN DESA, 2017) and international migration is the stream over the world. In Asia, 80 million people are migrants, of whom 63 million people (60%) are from another part of Asia and the population migrating from Asia to Asia is the largest share of international migration in the world (UN, 2017). Moreover, Asia gained 30 million international migrants between 2000 and 2017 which is the fastest growing number in the world (UN, 2017). International Organization for Migration (IOM) announced labor migration accounts for 150.3 million as of 2015, which is about 60% of the 258 million international migrants and the number is increasing (IOM, 2018). The 'UN International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families' defines a migrant worker as followed: "person who is to be engaged, is engaged or has been engaged in a remunerated activity in a state of which he or she is not a national." (IOM, 2011). Labor migration between countries and continents is now a permanent feature of the global economy (Mekkodathil *et al.*, 2016).

Migrant workers have greater adverse occupational exposures and worse working conditions than native workers, resulting in adverse health outcomes such as fatal occupational injuries (Moyce & Schenker, 2018). Though the health inequity is the major issue on public health, a few studies on migrant workers' OSH have only been conducted in high-income countries such as the United States and Western Europe countries. There has been no systematic review of the literature on OSH of migrant workers, particularly fatalities due to occupational injuries, and few studies have investigated the related

risk factors. The poor working conditions of migrant workers result in negative health outcomes due to, for example, their low educational level (Loh & Richardson, 2004), low skill level (Mekkodathil *et al.*, 2016; Tuma *et al.*, 2013), and non-use of personal protective equipment (Al-Thani *et al.*, 2015). However, few studies have evaluated the role of structural risk factors, such as the need to ensure that recruiting systems do not adversely affect the OSH of migrant workers. A cross-national comparative study would be optimal; however, occupational injuries/diseases statistics are not directly comparable among countries due to, for example, differences in the criteria for identifying migrant workers and data collection methods.

South Korea is one of the major destination countries for migrant workers in Asia and has a two-component system for recruiting migrant workers. All non-professional migrant workers in South Korea are under the employment permit system (EPS), which consists of the working-visit and dependent-employment systems. The EPS instituted a government-to-government labor recruitment program to reduce the cost of migration, the majority of which is debt (ILO, 2016), a major cause of overwork among migrant workers (Wickramasekara, 2013). Despite the reduction in the cost of migration, the EPS has not enhanced the OSH of migrant workers. The rate of occupational injuries and diseases among migrant workers increased from 0.96% in 2007 (when the EPS was initiated) to 1.08% in 2014, while the rate among native workers decreased from 0.71% to 0.51% during the same period (Korean Immigration Service, 2018; Ministry of Employment and Labor, 2018a).

The two migrant worker recruitment systems can be evaluated by comparing groups of migrant workers of Chinese

nationality with similar migration histories. Korean–Chinese and Chinese migrant workers share a language and culture because they are of the same nationality. Korean–Chinese people account for 95.7% of all workers of Korean descent (Korea Employment Information Service, 2014) and in September 2018, less than 41.1% (n = 215,665) of documented migrant workers were of Chinese nationality (Korean Immigration Service, 2018). Korean–Chinese people are the descendants of those who migrated to China after the 19th century due to famine, natural disasters, and the conquest of Korea by Japan, but did not return when the Communist Party of China came to power in 1949 and severed diplomatic relations with South Korea (Castles *et al.*, 2015). In the late 1980s, when South Korea was in the midst of rapid economic development, Korean–Chinese migrants entered the country to visit relatives and began to sell Chinese goods. In the early 1990s, the South Korean government began to allow the entry of migrant workers of other nationalities. Migrant workers can be hired only by small and medium–sized companies unable to recruit suitable native workers.

Chinese migrant workers who are not of Korean descent cannot obtain work permits, and are employed by companies granted permission by the government; thus, such workers are dependent on their employer (UNAOC, 2014). The dependent–employment permits granted to such migrant workers mandate that they not work for another employer unless the current employer breaks the law or closes. In contrast, Korean–Chinese migrant workers can obtain work permits after they find employment. Therefore, in South Korea there are two groups of migrant workers of Chinese nationality, and these two groups use different recruitment systems. Korean–Chinese and Chinese migrant workers also may differ in terms of their ability to

change jobs, Korean language proficiency, and whether they have relatives in South Korea. These factors may impact the fatality rate of occupational injury (FROI). The risk factors for adverse occupational exposures and working conditions for migrant workers include a lack of labor rights, restricted access to family and other support systems (Mekkoathil *et al.*, 2016), and the xenophobic political climate of the host country (Moyce & Schenker, 2018).

This study consisted of two studies and they separated by chapters. Chapter 1 is a systematic literature review compared OSH of migrant workers and native workers in each Asian country. The research questions of the first chapter were 1) Did migrant workers from Asia migrating to Asia have higher fatality rates due to occupational injury than the native workers' in the destination country?, 2) In which industry or occupation was the highest fatal occupational injury rate of migrant workers?, and 3) What was the main mechanism of fatal occupational injuries for migrant workers?. Narrowing down to one country level, chapter 2 aimed to determine whether the FROI differs between Korean–Chinese and Chinese migrant workers and identified the risk factors for fatal occupational injuries among migrant workers in South Korea. This is the first study on the effects of structural factors, e.g., the prohibition on changing workplaces, on the FROI of migrant workers.

Chapter 1. Occupational Deaths among Asian Migrant Workers: A Systematic Review

1.1. Method

1.1.1. Searching strategy

The systematic review of the baseline in the field of health care was carried out according to the method proposed by National Evidence-based Healthcare Collaborating Agency's (NECA) guidance for undertaking systematic reviews and meta-analyses for intervention (Kim *et al*, 2011).

1.1.1.1. Searching Databases and Formula

The research was conducted using Internet-based electronic databases (DBs). The DBs used were PubMed, Science Direct, MEDLINE, and EMBASE.

The search formula used in this review got ideas from a backbone study (Fitzgerald *et al.*, 2013) and was modified to match the direction of this study. We changed the original search formula from the backbone study by excluding the word “peasant” and “China” in order to focus on migrant workers itself and include other parts of the world. Also, we added the word “work” , and

words related to outcome, which was related to deaths. The search formula was modified according to the DBs and its searching strategies and the basic composition was as follows; “(migrant* OR immigrant OR foreign) AND (occupation OR work OR works OR worker OR workers OR occupational OR labor OR labour OR industrial) AND (death OR fatality OR mortality) AND (injury OR accident* OR unnatural death)” (for more details, refer to the Appendix Table A.1).

1.1.1.2. *Inclusion and Exclusion Criteria*

The target population of this study was adult Asian migrant workers who migrated to Asia without gender restriction. We defined ‘adult’ as 18 years old and older by ILO child labor standard (ILO, 2018). ‘Asia’ was defined by the classification of the International Migration Report (UN, 2017) and included 51 countries as followed: Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan), Eastern Asia (China–mainland, Hong Kong SAR, Macao SAR, Dem. People's Republic of Korea, Japan, Mongolia, Republic of Korea (South Korea)), Southern Asia (Afghanistan, Bangladesh, Bhutan, India, Iran (Islamic Republic of), Maldives, Nepal, Pakistan, Sri Lanka), South–Eastern Asia (Brunei Darussalam, Cambodia, Indonesia, Lao People’s Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor–Leste, Viet Nam), Western Asia (Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, State of Palestine, Syrian Arab Republic, Turkey, United Arab Emirates, Yemen). Moreover, we included Taiwan, which is not a member state of the

UN, for a geographic reason.

Occupational injuries were defined as injuries in work-related activities including commuting in this study. Among the searched studies, we excluded those not associated with occupational injury and also limited the outcome which contained occupational fatalities of migrant workers. The reason for the limitation of occupational injuries was that occupational diseases can be difficult to verify work-relatedness or to detect due to the migrant workers' short stay in a host country, but the occupational injuries could be subject to a common standard in each country as it is easier to prove work-related under the definition. This study didn't limit study duration and study design because of the small number of concerning studies. All studies in English published before April 18, 2018, were included. Research reports not published in the Editorial or Journal were excluded. Therefore, the inclusion criteria were 1) 18 years old or older international Asian migrant worker who moves to Asia only (study population of this literature review), 2) published article, 3) study outcome should be included fatal occupational injury of migrant workers, 4) study subject about occupational injury, 5) written in English, 6) no duplicated and full text available.

1.1.2. *Study Selection Process*

We reviewed all the studies included in the data collection and screening process and confirmed that the results were consistent. If the evaluation results do not match, the documents were reviewed and agreed upon data selection or exclusion criteria. From four international DBs (PubMed, ScienceDirect, MEDLINE, EMBASE), a

total of 1,892 studies were searched and 909 duplicates were excluded. We reviewed the abstracts based on the data selection and exclusion criteria for 983 subjects and 898 were excluded by the screening. When the selection of the study was difficult from the abstract only, the full text was identified and confirmed. As a result, 72 were excluded from the eligibility process and the reasons for the excluded studies during full-text article screening were shown by Appendix Table A.2. Finally, a total of four studies were selected (Figure 1).

1.1.3. *Data analysis and extraction*

We created a basic form to accurately extract all the values needed for data analysis. The basic form included the study design, the study duration, the data source, the country or region where the study was conducted, the number of non-fatal or fatally injured migrant workers, the types of industry or occupation of migrant workers who got fatal injuries, the mechanisms of fatal injury and the object of the study. We conducted the extraction process independently and drew the agreement by comparing between the evaluation results.

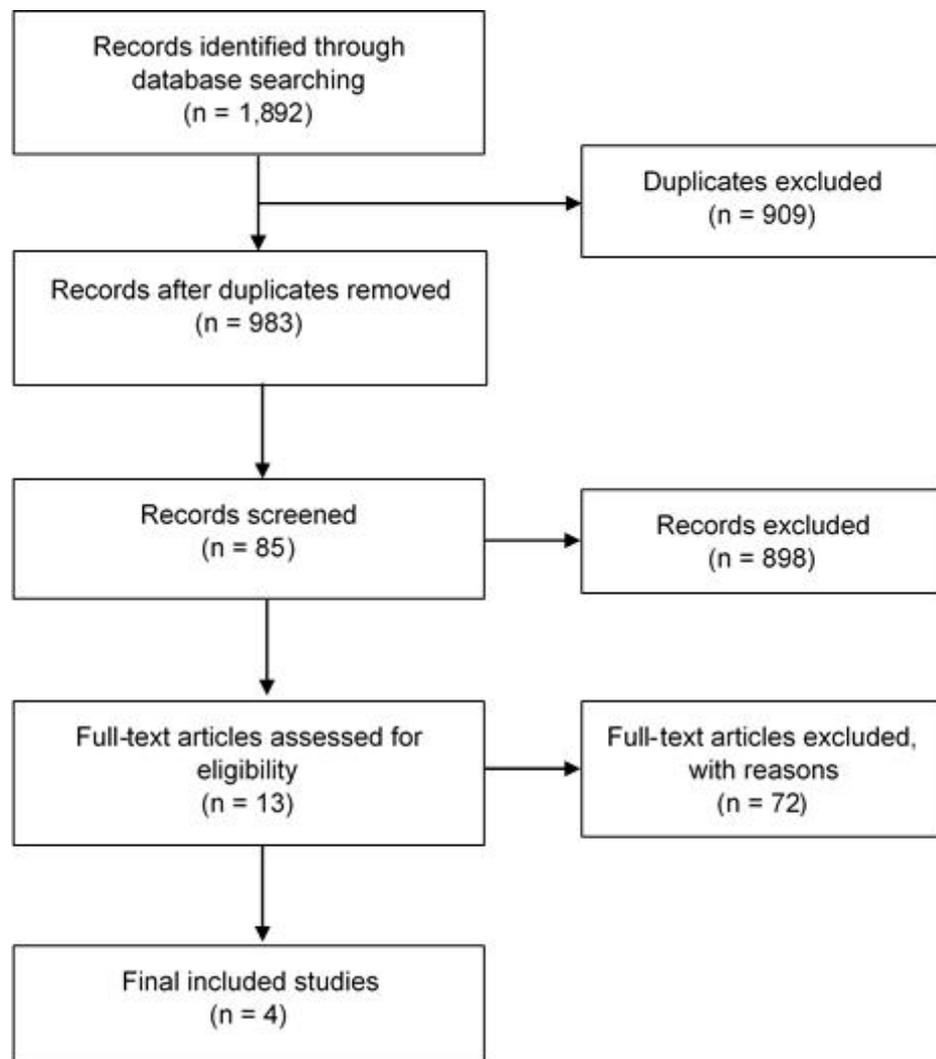


Figure 1. Flow diagram of study searching and selection

1.2. Results

1.2.1. Characteristics of selected studies

Only four studies were selected, and the studies' summary in Table 1 were based on the fatal occupational injuries of migrant workers in each country that this study sought to find out. There were no restrictions on the duration of the study and the design of the study, but they were all descriptive studies after the year 2000. The four selected studies were conducted in three major Asian migrant workers' destination countries: Qatar, Singapore, and South Korea, and two of which were from Qatar. Three studies from Qatar and Singapore based on hospital registry as the data sources, while the South Korea study used workers' compensation data as the source. All the studies have explained that the data source was representative of each country so that it can tell about the occupational deaths of migrant workers in Qatar, Singapore, and South Korea. The study populations were represented by the Asian migrant workers who had gotten occupational injuries, and calculated the fatality rate due to occupational injuries of migrant workers in each country.

The two studies (Cha & Cho, 2014; Al-Thani *et al.*, 2015), which have been studied for more than two years, showed that the total number of workers increased steadily over the years, while the number of migrant workers' deaths did not show a consistent tendency. Both studies showed there is no native worker's fatality (Al-Thani *et al.*, 2015) or the number of deaths in native workers

has been declining (Cha & Cho, 2014), but there was no clear explanation for the difference of occupational deaths' patterns between native workers and migrant workers in each country.

The criteria for the study populations in each of the selected studies were slightly different. One Qatar (Al-Thani *et al.*, 2014) and the Singapore studies based on hospital registry did not include workplace fatalities, of which them the Qatar article only included hospitalized injuries. Another hospital-based Qatar study (Tuma *et al.*, 2013) included workplace deaths in the count of the number of occupational fatalities but not workers who were not hospitalized either. South Korea study included both occupational injury and disease, fatal and non – fatal, but they could be separated for each case so that only fatal and non – fatal occupational injuries were analyzed in this study.

The terms used to describe migrant workers were slightly different, with the studies from Qatar (Al-Thani *et al.*, 2015) and South Korea using 'migrant workers' or 'non-national workers' , Singapore study describing them as 'foreign workers' or 'non-national workers' , and the other Qatar study (Tuma *et al.*, 2013) describing them as 'expatriate workers' . In this study, several idiomatic terms were unified as 'migrant workers' according to the IOM glossary (IOM, 2004). Each study referred to the definition of migrant workers or the nationality or ethnicity of those who were studied, so it was possible to identify them as Asian migrant workers who were study population to this study.

This study set the criteria for 'adult' migrant workers to be at least 18 years of age according to the ILO standards (ILO, 2018), but only one Qatar study (Al-Thani *et al.*, 2015) was the same. The

other Qatar study (Tuma *et al.*, 2013) was based on age 14 or older, but in fact, the youngest worker was 17 years old. Singapore study set the study population as 15 years old or older worker with a work-related injury who presented to the emergency department (ED) but we included the study because the mean age of ED admitted migrant workers was 30.1 (SD=6.3) year old. South Korea study was not specified for the age range.

The industries and occupations were listed in order of frequency of occupational injuries among migrant workers in each country, but one article (Tuma *et al.*, 2013) studied only the construction industry. 'Key findings' was compiled from the purpose of each study, the status of migrant workers, mechanisms of occupational fatal or non-fatal injuries, and fatal occupational injuries by nationality of migrant workers in each country.

The answers to the three research questions were summarized together with questions and presented in Table 2. Through the analysis of the four studies, we found that the patterns of migrant worker deaths in Qatar, Singapore, South Korea and these three countries were very similar.

Table 1. Summary of research on occupational injury of migrant workers

#	Author (year)	Study design/ Data source	Study population	Industry/ Occupation	Key findings
[1]	Carangan et al. (2004)	Hospital based survey descriptive study during 1998–1999 (for 6 months) / interviewed at urban public hospital's emergency departments and chart review for hospitalized interviewees in Singapore	1,936 migrant workers, (1,244 native workers, total 3,180 workers): fatality rate = 0.15% (3 fatalities of migrant workers)	unknown	<p>*Study object: to compare the patterns of work-related injuries sustained by migrant workers and native workers.</p> <p>*Different day patterns of injuries: Friday and Saturday for migrant workers vs. Wednesday and Monday for native workers</p> <p>*Mechanism of injury: fall from height over 2m frequently occurred among migrant workers (9.1%) than native workers (4.3%) and resulting in 2/3 migrant workers death.*Mechanism of three deaths: fall from height (2 migrant workers), hitting by heavy machinery (1 migrant worker) *Site of injury for fatalities: two multiple injuries(from fall from height) and one unreported(from hit by heavy machinery)</p> <p>*Occupational injuries by nationality (top 3): Indian, Bangladeshi, China</p>
[2]	Tuma et al.(2013)	Hospital based survey descriptive study during	289 construction migrant workers who got injured related fall from	Only Construction workers	<p>*Study object: to identify the injury burden and the financial losses due to these preventable work-related accidents in Qatar.</p>

	<p>2007–2008 (for 12 months) / database registry of Hamad general hospital in Qatar</p>	<p>height (9 native workers, total 298 workers): fatality rate = 10.03% (29 fatalities of migrant workers, including 17 pre-hospital deaths)</p>	<p>were studied</p>	<p>*Mechanism of occupational injury for migrant workers: fall from a height mostly 3m or greater (75%) *Site of injury (top 3): spine(41%), head(38%), chest(28%) -the percentage do not add up to 100% because there are patient who got multiple site injuries.</p>
<p>[3]</p>	<p>Cha & Cho (2014) Cross-sectional descriptive study during 2005–2007 (for 3 years) / National occupational injury compensation insurance data in South Korea</p>	<p>9,801 migrant workers who claimed workers' compensation for injuries (240,379 native workers, total 250,180 workers): fatality rate = 2.09% (205 fatalities of migrant workers)</p>	<p>Construction (almost 24-fold higher risk of a fatal injury in 2007, compared with native workers), manufacturing</p>	<p>*Study object: to provide numbers and proportions of work-related injuries, to evaluate temporal patterns, to describe trends, and to investigate the relative risks of fatal and non-fatal work-related injuries among migrant workers compared with native workers. *Risks of fatal and non-fatal occupational injuries for migrant workers were considerably higher than native workers. *Mechanism of occupational deaths for migrant workers: falling, rolled/jammed, fire, electric shock, collapse, stricken by a flying object, collision *Industry adjusted standard mortality ratios for fatal occupational injuries of migrant workers: 1.89(in 2005), 2.29(in 2006), 1.73(in 2007).</p>

[4]	Al-Thani et al. (2015)	Hospital-based survey descriptive study during 2010–2013 (for 4 years) / Trauma registry from Hamad general hospital, Qatar	1,993 migrant workers who were admitted (22 native workers, total 2,015 workers): fatality rate = 4.32% (86 fatalities of migrant workers)	General laborer, transportation & material moving worker, repair & carpentry worker, housekeeping worker	<p>*Study object: 1) to provide an evidence base for the formulation of recommendations to improve occupational safety, 2) to inform the ‘source countries’, employers and labor officials about the highest risks for migrant workers in order to help target interventions and to promote prospective occupational surveillance systems in Qatar.</p> <p>*1.26 million migrant workers, 94% (84% male, 10% female) of the total workforce in 2012, mainly from South Asian countries and their risks of occupational injuries and fatalities were increased.</p> <p>*Mechanism of severe occupational injury formigrant workers: fall from height, fall of heavy objects, motor vehicle crashes, machinery.</p> <p>*Fatal occupational injuries by nationality (top 3): Indian, Nepalese, Bangladeshi.</p>
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The number is in the order of the year of publication

Table 2. Answers of each study for research questions

Research questions	#	Answer
Did migrant workers from Asia migrating to Asia have higher fatality rates due to occupational injury than the native workers' in the destination country?	[1]	Yes
	[2]	Yes
	[3]	Yes
	[4]	Yes
In which industry or occupation was the highest fatal occupational injury rate of migrant workers?	[1]	Unknown
	[2]	Construction (the only studied industry)
	[3]	Construction
	[4]	Construction
What was the main mechanism of fatal occupational injuries for migrant workers?	[1]	Fall from height over 2m
	[2]	Fall from height (mostly over 3m)
	[3]	Falling
	[4]	Fall from height

1.2.2. *Did migrant workers from Asia migrating to Asia have a higher fatality rates due to occupational injury than the native workers' in the destination country?*

All studies indicated that migrant workers in any destination country had higher fatality rates due to occupational injury than that of native workers (Table 1, Table 2). In Qatar, migrant workers are overwhelming at 94% of the total workforce as of 2012, so the number of injured migrant workers was bigger ([4], Al-Thani *et al.*, 2015). All occupational deaths in the Qatar study ([2], Tuma *et al.*, 2013: [4], Al-Thani *et al.*, 2015) were migrant workers. Migrant

workers in Singapore showed 1.6 times more often causing work-related injury than native workers, and all three of the fatal hospitalized workers were migrant workers ([1], Carangan *et al.*, 2004). The South Korea study calculated industry-adjusted standard mortality ratios of fatal occupational injuries and the result said migrant workers had steadily almost 2 times higher than native workers' risks of fatal injuries ([3], Cha & Cho, 2014).

1.2.3. *In which industry or occupation was the highest fatal occupational injury rate of migrant workers?*

The three studies pointed out construction as the industry of the highest fatal occupational injury rate for migrant workers and these researches were conducted in Qatar and South Korea ([2], Tuma *et al.*, 2013; [3], Cha & Cho, 2014; [4], Al Thani *et al.*, 2015) (Table 1, Table 2). One of which only covered the fall from a height of the construction sector ([2], Tuma *et al.*, 2013) because it said that the construction industry is the leading cause of occupational death in Qatar. The other Qatar study only talked about the occupations having the highest rate of occupational injury were general laborer, with a lack of explanation as to what kind of work they usually do. The industry borrowed the results of previous studies by the same first author and mentioned occupations and industries in a mixed way ([4], Al Thani *et al.*, 2015). In South Korea, especially in the construction sector, migrant workers were at an almost 24-fold higher risk of a fatal injury, compared with their Korean counterparts and the second highest one was manufacturing

sector ([3], Cha & Cho, 2014). Singapore's study did not mention industries or occupations that showed the highest fatality rate of occupational injury because the industry of migrant and native workers were different. As the study pointed out the limitation, the researchers prevented direct comparison however cited construction as a typical example, saying migrant workers mainly reported “lower skill industries” , “blue-collar sectors” , and “physically demanding labor-intensive work” ([1], Carangan *et al.*, 2004).

1.2.4. *What was the main mechanism of fatal occupational injuries for migrant workers?*

Fall from height was the most common mechanism of fatal occupational injuries in Qatar, Singapore, and South Korea (Table 1, Table 2). There were two studies that indicated the height of the fall, over 3m ([2], Tuma *et al.*, 2013) and over 2m ([1], Carangan *et al.*, 2004), but other two studies did not distinguish between them. Migrant workers in Qatar had fatal injuries from falling with increasing demands for construction work like making soccer stadiums for the World Cup in 2022 ([4], Al-Thani *et al.*, 2015). The study cited fall from height as major contributors for occupational risk factor but did not mention the number of deaths or fatality rate by the mechanism of fatal occupational injuries. The Singapore study found that the Injury Severity Score (ISS) for workers who fell from more than 2m high averaged 8.3, significantly higher than the average ISS 3.6 for other traumas ([1], Carangan *et al.*, 2004). Most of the injured workers from falling were affected head and spine ([2], Tuma

et al., 2013).

1.3. Discussion

The purpose of this study was to compare the deaths caused by occupational injuries of adult Asian migrant workers migrating to Asia to native workers in each country by systematic literature review, and to find out the most lethal industries or occupations and their mechanisms. Although there were no limitations on the study period or duration and research design, only the four articles studied in the three countries were selected as inclusion criteria from 1,892 articles. The comparisons of inter nations, however, should be treated cautiously due to differences in sources, accuracy, and completeness of the data and the definition of occupational fatal injury so we selected articles within this study's inclusion criteria and marked minor differences of the selected articles. The result of this study showed migrant workers in selected destination countries had higher fatality rates due to occupational injury than that of native workers. The industry or occupation of the highest fatal occupational injury rate for migrant workers was the construction industry and fall from height was the most common mechanism of them.

19 studies of the 72 excluded papers outlined the global OSH situation for migrants, seven of which were on the global burden of disease. The U.S. and China had the largest number of papers, seven each, as a single country, but the studies were excluded because the study populations of them were non-Asian or domestic migrant

workers. China's researches about native or internal migrant workers were all excluded based on the inclusion criteria of this study as international Asian migrant workers. Among Asia's major destination countries of migrant workers, studies from Japan, Malaysia, Taiwan, and China could not be found.

A previous study estimated that global loss from fatal and non-fatal occupational injuries was about 10.5 million people per year and about 3.5 years of healthy life lost per 1,000 workers (Benach *et al.*, 2007). Worldwide, 2.3 million workers die due to occupational injuries and diseases annually (ILO, 2014a), of which 1.1 million workers are from Asia and the Pacific (ILO, 2019). Despite wide variations between countries, occupational injuries affect the national interest of up to 4% reducing (Wilson *et al.*, 2007). Despite their importance, occupational injuries, including fatal ones, were rarely investigated in developing countries (Rabi *et al.*, 1998). A literature review in 2016 analyzed workers' occupational injuries according to the regional classification of ILO statistics, but it mostly cited examples of the United States, Europe countries and Australia due to differences in statistics and the number of studies (Mekkoathilet *et al.*, 2016). In Asia, 12 % of the countries did not provide recent data on the number of international migrants, while 26 % were lacking recent data on the age of international migrants, and 32 % on the origin of international migrants (UN, 2017). The reasons for the lack of research in Asia could be a deficiency of current epidemiological tools and methods (Schenker, 2011) or written in languages other than English.

In contrast, Nepal is one of the major countries of origin for migration in Asia, the 14% of the total population which is 3.5 million people is migrant workers and their remittances contribute greatly to

the national economy (Simkhada *et al.*, 2017). Nepal was the only origin country to study the deaths of Nepalese migrant workers, and the two studies show that many Nepalese migrant workers' OSH is in serious condition (Aryal *et al.*, 2016; Simkhada *et al.*, 2017), and moreover, one-quarter of the deaths' causes are unknown (Aryal *et al.*, 2016). It is essential for migrant workers' destination countries as well as their origin countries to be aware of the workers' OSH situation and come up with countermeasures.

Migrant workers are not a homogenous group. There are emerging questions. Mental health problems and gender issues among migrant workers. The selected studies reported male-dominated migrant workers, and only in a Singapore study said that the proportion of female migrant workers was lower than that of female native workers. Majority of female migrant workers is domestic workers and the largest share in South-Eastern Asia and the Pacific countries. Female migrant domestic workers are around 8.5 million (73.4% of all migrant domestic workers) and 24% of the world's female migrant domestic workers are in Asia as of the year 2013 (ILO, 2015). Compared to the early 2000s, the number of migrant workers increased significantly, among them, the proportion of female migrant workers have become similar to that of male migrant workers. Although the number of occupational deaths among female migrant workers is not as high as that of male workers, there is a need to monitor and prevent occupational injuries by different aspects of the industry. Female migrant workers have a different level of occupational risks compared to male migrant workers due to the majority working in the care industry. Particular attention needs to be paid to the fall and burn of the female domestic migrant worker.

This review has a limitation that the selected studies were

restricted to English only. Studies written in other languages for each country were excluded due to the language barrier of the researchers. Also, publication bias may exist. The proper review could be made by international co-research which can include studies written in other languages from relevant databases in each country. In addition, this review included only a handful of variations in countries due to the lack of studies of migrants. There is a lot of contextual, societal and cultural background to migrant workers and a number of countries need to be reviewed to make a more specific conclusion for Asian workers to Asia migration. A hospital-based study could have a selection bias due to lack of information on the population of migrant workers but we included these studies because there were few studies and surveys and descriptive study have a role of awareness of the problems. Also, the high probability of underreporting could be another problem. Also, another limitation of these studies is that migrant workers' population is regarded as a homogenous group and analysis according to legal status or stay duration has not been included. Particularly in the era of the feminization of migration, research on female migrant workers is indispensable but not has been found. It is necessary to carry out accident monitoring and reporting properly in order to prevent the death of migrant workers and to prevent their recurrence.

Though these limitations, this study could see the fatality rate of occupational injuries, the riskiest industry and the mechanisms of fatal injuries of migrant workers in Asia countries. This study is meaningful as the first study to examine the systematic literature on the occupational fatal injury of migrant workers who migrated from Asia to Asia. The difference in OSH among migrant workers and native workers is a major public health problem that shows the

inequity of workers' health.

Chapter 2. Factors Associated with Fatal Occupational Injuries Among Chinese Migrant Workers in South Korea: Effect of Type of Employment Permit

2.1. Materials and Methods

2.1.1. Data

We used the Korea Workers Compensation and Welfare Services (KCOMWEL) Status of Occupational Injuries and Diseases of Migrant Workers data from January 2007 to September 2018. The KCOMWEL is a national agency that manages all claims for compensation due to occupational injuries and diseases. Raw de-identified data were obtained from the KCOMWEL website (www.kcomwel.or.kr) through an information request system. The study was approved by the Institutional Review Board of Seoul National University (no. E1902/003–005).

The data comprised work-related injuries and diseases with fatal and non-fatal outcomes, causes and sites of injuries, demographic variables (*e.g.*, sex, age, and nationality), and employment variables (*e.g.*, occupation and industry). According to the KCOMWEL definitions, occupational injuries were defined as those that occurred while workers were engaged in work-related activities,

including commuting (after 2018), that required >4 days of medical treatment. From 2007 to 2018, there were a total of 71,593 occupational injury or disease compensation claims, among which 42,089 were filed by migrant workers of Chinese nationality. The exclusion criteria were as conservative as possible to ensure generation of reliable results. Selection of the study population is shown in Figure 2.

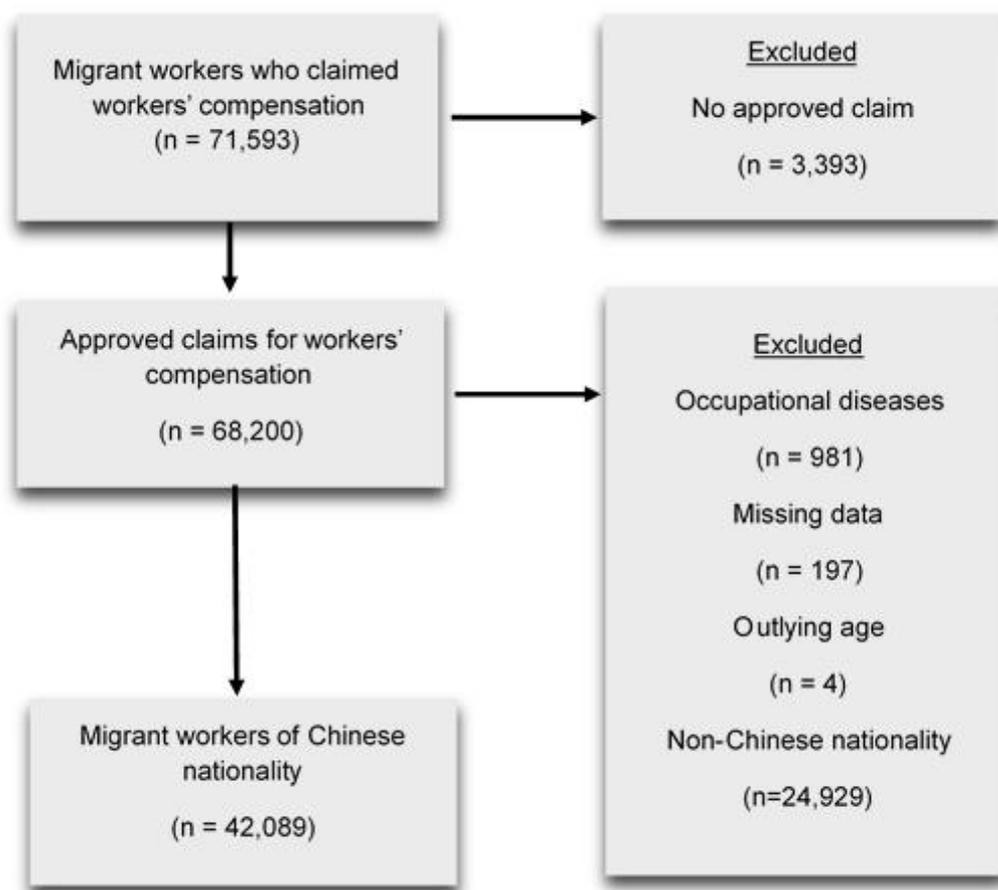


Figure 2. Selection of the study population

The study population comprised migrant workers of Chinese nationality whose workers' compensation claims due to occupational injuries were approved. We defined migrant workers as persons of non-Korean nationality working under the EPS irrespective of their legal status. The Ministry of Employment and Labor of South Korea has as of September 2018 issued memoranda of understanding on migrant workers with the governments of China, Vietnam, Sri Lanka, Uzbekistan, Indonesia, Thailand, the Philippines, Nepal, Mongolia, Pakistan, Bangladesh, Cambodia, Myanmar, Kyrgyzstan, East Timor, and Laos (Ministry of Employment and Labor, 2018b). The population of South Korea includes 2.3 million immigrants (>4%), among whom 525,000 are documented workers under the EPS. These workers originated from China (41.1%, 215,665 workers), Cambodia (7.5%, 39,122), Vietnam (7.3%, 38,075), and Nepal (6.5%, 33,906) at the end of September 2018 (Korean Immigration Service, 2018). As of the second half of 2018, 522,595 migrant workers were employed by companies that are members of the Korea Workers Compensation Insurance, which covers 67,138 workplaces (Korean Statistical Information Service, 2018).

2.1.2. Measures

This observational cross-sectional study evaluated risk factors for fatal occupational injuries by comparing the FROIs of two groups of migrant workers of Chinese nationality. The FROI is defined as the proportion of occupational deaths among migrant workers with occupational injuries. We used FROI as the outcome variable because

the death count was the most reliable measure due to the high rates of underreporting, particularly of migrant workers, in South Korea. According to the OSH Research Institute of South Korea, over 70% of migrant workers who suffered an occupational injury failed to file claims for workers' compensation (Yi & Cho, 2012). A high FROI may indicate a large number of occupational deaths or a small number of injuries. A large number of deaths is meaningful in itself in identifying the situation, and the small number of injuries is due to the high underreporting rate. Poorer organizational safety climate including management values, safety communication, safety training, and safety systems leads to higher underreporting rate (Probst & Estrada, 2010). We thus assumed that the incidence of occupational injuries among migrant workers in South Korea had been underestimated. The FROI of Korean-Chinese migrant workers was used as the reference.

Korean-Chinese migrant workers have the right to employment of their choice under the working-visit system of the EPS. To assess the effect of the prohibition on changing workplaces, we compared the FROIs of Korean-Chinese and Chinese migrant workers with adjustment for year, sex, age, occupation, industry, and site of injury. Since the start of the EPS, there have been two revisions to the law on the workplace change of migrant workers since October 9, 2009 and February 1, 2012. Migrant workers with dependent permit may apply for a workplace change only with special reasons. The two revisions expanded the scope of the "special reasons"(2009) and made clarify the reasons with examples(2012). We divided the research period into three parts around the revised year to see the effects of the related policy. The workers were 15 to 104 years of age, but we used the quintiles from 15 to 81 years of

age after excluding four outliers (>90 years of age).

The employment of migrants is tightly controlled by the EPS with regard to both the annual number and the type of positions. The occupations classified by the seventh Korea Classification of Occupational Standards were divided into the four employment categories in which migrant workers were most frequently employed: manager and service worker; agriculture, livestock, and fisheries worker; machine operator; and elementary worker. Managers and service workers were grouped due to the low fatality rates of these categories. Considering that only non-professional migrant labor is permissible by the EPS, we interpreted “manager” to indicate a worker who has worked a little longer than other workers in their field, or an independent business owner. “Machine operator” included craft and related trades workers, equipment or machine operators, and assembly workers (e.g., food processing, wood and furniture, dyeing and molding, and metal casting workers).

Nine industries were classified into five categories in which migrant workers could be employed: manufacturing, construction, service, agriculture, livestock, and fisheries. However, because there were few claims for workers’ compensation from the agriculture, livestock, and fisheries industries, we treated these as a single unit—agriculture, livestock, and fisheries (ALF). Further, the transportation and delivery industries were classified as other, and the sales, food, and accommodation sectors were pooled as the service industry, in which Korean-Chinese workers account for 93.3% of the migrant workers (Korea Employment Information Service, 2013). The site of injury leading to death was classified according to the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10), as head and neck, extremity, trunk, and

whole body (including multiple-site injuries).

2.1.3. Statistical analysis

The data from 42,089 migrant workers of Chinese nationality were analyzed in three stages. First, the chi-squared test was used to determine whether the FROI was significantly different according to the characteristics of the study population. Second, the difference in the FROI of each covariate was compared between the Korean-Chinese and Chinese migrant workers. Third, we identified risk factors for fatal occupational injuries by logistic regression with adjustment for covariates. R software (version 1.0.153) was used to conduct all statistical analyses.

2.2. Results

2.2.1. FROI by characteristics

The FROIs of the study population are listed in Table 3. The FROI did not differ significantly between the Korean-Chinese and Chinese migrant workers according to their characteristics.

Male workers had a higher FROI (1.89%) than female workers (0.48%). The FROI increased with age, and machine operators had the highest FROI (2.34%), followed by ALF workers (1.74%), and elementary workers (1.36%). The industry with the highest fatality rate was construction (2.74%), followed by ALF (2.23%). The

service and other industries had similar fatality rates, but the former had a lower FROI. The most frequent causes of mortality were whole-body injuries (25.95%) and head-and-neck (7.36%) injuries. The most frequent cause of a claim for compensation was injury to the extremities. The whole-body injuries included fall from a height, systemic burns, poisoning, multiple injuries, suffocation, and drowning.

Table 3. FROI^a according to subjects' characteristics (chi-squared test) (N=42,089)

Variables	Total	N		FROI ^a		p-value
		42089	%	N	%	
Group				686	1.6	0.9738
Korean-Chinese	32987	78.4	538	1.6		
Chinese	9102	14.0	148	1.6		
Year						<0.01
2007-2009	7515	17.9	174	2.3		
2010-2011	14765	35.1	250	1.7		
2012-2018	19809	47.1	262	1.3		
Sex						
Female	7875	18.7	38	0.5		
Male	34214	81.3	648	1.9		
Age						<0.01
15~28	2130	5.1	16	0.8		
29~36	5134	12.2	62	1.2		
37~44	8307	19.7	110	1.3		
45~53	13737	32.6	234	1.7		
54~81	12781	30.4	264	2.1		
Occupation						<0.01
Manager & Service worker	9248	22.0	84	0.9		
ALF ^b worker	516	1.2	9	1.7		
Machine operator	15665	37.2	367	2.3		
Elementary worker	16660	39.6	226	1.4		
Industry						<0.01

Manufacturing	16845	40.0	186	1.1	
Construction	13873	33.0	380	2.7	
ALF ^b	1166	2.8	26	2.2	
Service	6772	16.1	45	0.7	
Others	3433	8.2	49	1.4	
Site of Injury					<0.01
Head & Neck	4703	11.2	346	7.4	
Extremity	31542	75.0	30	0.1	
Trunk	5031	12.0	99	2.0	
Whole body	813	2.0	211	26.0	
^a Fatality Rate of Occupational Injury					
^b Agriculture, Livestock and Fisheries					
Note: All estimates were from chi-squared test					

Female and male migrant workers differ greatly in the number of claims and deaths. Because gender differences are large, there may be many interactions even if gender is corrected, so we wanted to separate gender and logistic regress them to identify differences in each category of variables into two models (Table 4 & Table 5). Model 1 is the death difference between the Chinese and Korean-Chinese groups after controlling age, occupation and industry, and Model 2 is the additional control of the year variables.

Table 4. Comparison of Odds Ratios of Occupational Injury to Male Migrant Workers in Two Models (N=34,214)

Variables	Model1		Model2	
	OR ^a	95%CI ^b	OR ^a	95%CI ^b
Group				
Korean-Chinese	1.0	-	1.0	-

Chinese	1.2	1.0-1.4	1.1	0.9-1.4
Age				
15~28	1.0	-	1.0	-
29~36	1.6	0.9-2.7	1.5	0.9-2.7
37~44	1.5	0.9-2.6	1.5	0.9-2.6
45~53	2.1	1.2-3.6**	2.1	1.2-3.6**
54~81	2.5	1.4-4.2**	2.6	1.5-4.5**
Occupation				
Manager&Serviceworker	1.0	-	1.0	-
ALF ^c worker	0.8	0.4-1.7	0.8	0.4-1.8
Machine operator	1.3	1.0-1.8	1.3	0.9-1.8
Elementary worker	0.8	0.6-1.1	0.8	0.5-1.1
Industry				
Service	1.0	-	1.0	-
Manufacturing	0.9	0.5-1.3	0.8	0.5-1.3
Construction	1.8	1.2-2.8**	1.9	1.2-2.9**
ALF ^c	1.6	0.9-2.9	1.5	0.8-2.7
Others	1.1	0.7-1.7	1.0	0.6-1.7
Year				
2007-2009			1.0	-
2010-2011			0.7	0.6-0.9**
2012-2018			0.5	0.4-0.6**
^a OR: OddsRatio				
^b CI: Confidence Interval				
^c Agriculture, Livestock and Fisheries				
*p<0.05,**p<0.01				
Note: Estimates were obtained by logistic regression adjusted for sex, age, occupation, industry for model1.				

Table 5. Comparison of Odds Ratios of Occupational Injury to Female Migrant Workers in Two Models (N=7,875)

Variables	Model1		Model2	
	OR ^a	95%CI ^b	OR ^a	95%CI ^b
Group				
Korean-Chinese	1.0	-	1.0	-
Chinese	1.7	0.8-3.6	1.6	0.8-3.4
Age				

15~28	1.0	-	1.0	-
29~36	1.1	0.1-12.0	1.1	0.1-11.8
37~44	2.5	0.3-20.1	2.3	0.3-18.9
45~53	1.5	0.2-11.8	1.5	0.2-12.4
54~81	2.2	0.3-18.4	2.7	0.3-21.9
Occupation				
Manager&Serviceworker	1.0	-	1.0	-
ALF ^c worker	0.0	0.0-inf	0	0.0-inf
Machine operator	4.9	1.8-13.1**	4.8	1.7-13.4**
Elementary worker	0.9	0.3-3.0	0.9	0.3-3.2
Industry				
Service	1.0	-	1.0	-
Manufacturing	1.0	0.3-3.3	0.9	0.3-3.3
Construction	7.6	2.7-21.3**	7.5	2.6-21.6**
ALF ^c	2.4	0.3-23.2	2.4	0.2-25.1
Others	0.4	0.0-3.8	0.4	0.0-4.1
Year				
2007-2009			1.0	-
2010-2011			0.6	0.3-1.3
2012-2018			0.4	0.2-0.8*
^a OR: OddsRatio				
^b CI: Confidence Interval				
^c Agriculture, Livestock and Fisheries				
*p<0.05,**p<0.01				
Note: Estimates were obtained by logistic regression adjusted for sex, age, occupation, industry for model1.				

There were no significant differences in the causes of death due to occupational injuries according to the subjects' characteristics (Table 6). Collision (including fall from a height, struck by a flying object, and pinned under a collapsed structure) was the most common cause of mortality due to occupational injury for all occupations and industries. The deaths of machine operators had various causes, among which collision was the most frequent; the rates of other causes of mortality were similar. Cuts were the second most frequent cause of death among machine operators and elementary workers, and involved hypovolemic shock caused by stabbing or amputation. More

than half of the deaths of workers in the construction industry were due to collision. Suffocation was caused by fire, explosion, poison, and drowning, and was the second most frequent cause of occupational mortality in the service industry. The rate of suffocation among Chinese workers (20.27%) was higher than that among Korean-Chinese migrant workers (11.36%). Although rolling/jamming was not always fatal, it was the major cause of permanent disability of migrant workers. In some cases the cause of mortality was not identified; these cases were classified as "other".

Table 6. Mechanisms of deaths due to occupational injuries according to subjects' characteristics (N=686)

	Collision		Cuts		Suffocation		Rolling/Jamming		Others	
	N	%	N	%	N	%	N	%	N	%
Group										
Korean-Chinese	278	51.77	101	18.81	61	11.36	33	6.15	64	11.92
Chinese	75	50.68	23	15.54	30	20.27	9	6.08	11	7.43
Occupation										
Manager & Service worker	44	52.38	11	13.10	19	22.62	3	3.57	7	8.33
ALF ^a worker	4	44.44	1	11.11	4	44.44	0	0.00	0	0.00
Machine operator	184	50.14	66	17.98	50	13.62	25	6.81	41	11.17
Elementary worker	121	53.54	46	20.35	18	7.96	14	6.19	27	11.95
Industry										
Manufacturing	71	38.17	40	21.51	25	13.44	29	15.59	20	10.75
Construction	222	58.42	67	17.63	39	10.26	6	1.58	46	12.11
ALF ^a	13	50.00	4	15.38	7	26.92	2	7.69	0	0.00
Service	17	37.78	6	13.33	13	28.89	1	2.22	8	17.78
Others	30	61.22	7	14.29	7	14.29	4	8.16	1	2.04

^aAgriculture, Livestock and Fisheries

2.2.2. FROIs of Korean–Chinese and Chinese migrant workers

The FROI of the Chinese migrant workers according to their characteristics was equal to or greater than that of Korean–Chinese migrant workers (Table 7). The arithmetic average age of Korean–Chinese migrant workers was 48.2 years (median 49 years), compared to an average age of 43.79 years (median 44 years) for Chinese migrant workers. The FROI of Chinese migrant workers with ALF jobs (2.55%) was higher than that of Korean–Chinese migrant workers doing the same work, and higher than that of Chinese migrant workers doing other jobs.

Table 7. FROI^as of Korean–Chinese and Chinese migrant workers (N=42,089)

Variables	Korean-Chinese (N=32,987)			Chinese (N=9,102)		
	N	Death	FROI ^a (%)	N	Death	FROI ^a (%)
Sex						
Female	6114	26	0.4	1761	12	0.7
Male	26873	512	1.9	7341	136	1.9
Year						
2007-2009	5109	105	2.1	2406	69	2.9
2010-2011	12205	221	1.8	2560	29	1.1
2012-2018	15673	212	1.4	4136	50	1.2
Age						
15~28	873	1	0.1	1257	15	1.2
29~36	3653	39	1.2	1481	23	1.6
37~44	6282	78	1.2	2025	32	1.6
45~53	11552	192	1.7	2185	42	1.9

54~81	10627	228	2.2	2154	36	1.7
Occupation						
Manager & Service worker	7415	68	0.9	1833	16	0.9
ALF ^b worker	359	5	1.4	157	4	2.6
Machine operator	12531	288	2.3	3134	79	2.5
Elementary Worker	12682	177	1.4	3978	49	1.2
Category of Business						
Manufacturing	12533	143	1.1	4312	43	1.0
Construction	11413	298	2.6	2460	82	3.3
ALF ^b	931	21	2.3	235	5	2.1
Service	5334	35	0.7	1438	10	0.7
Others	2776	41	1.5	657	8	1.2
Injury Site						
Head & Neck	3720	282	7.6	983	64	6.5
Extremity	24493	24	0.1	7049	6	0.1
Trunk	4148	79	1.9	883	20	2.3
Whole body	626	153	24.4	187	58	31.0
^a Fatality Rate of Occupational Injury						
^b Agriculture, Livestock and Fisheries						

In order to find out more about the differences between two groups, Chinese migrant workers compared to Korean-Chinese migrant workers in each subgroup was shown as odds ratios in Table 8.

Table 8. Fatality comparison of occupational injuries between Chinese and Korean-Chinese migrant workers by subgroups (N=42,089)

Variables	Crude OR ^a	95% CI ^b	Adjusted OR ^a	95% CI ^b
Korean-Chinese	1.0	—	1.0	—
Chinese	1.0	0.8-1.2	1.2	1.0-1.5*
Chinese				

Sex				
Female	1.7	0.9-3.5	2.1	1.0-4.5
Male	0.6	0.3-1.2	0.5	0.2-1.0
Age				
15~28	60.6	7.9-462.6**	68.6	8.8-536.8**
29~36	2.4	1.4-4.1**	2.5	1.4-4.3**
37~44	1.6	1.0-0.2**	1.6	1.0-2.6*
45~53	0.7	0.5-1.1	0.7	0.5-1.1
54~81	0.4	0.3-0.7**	0.4	0.3-0.7**
Occupation				
Manager&Serviceworker	0.8	0.5-1.5	0.6	0.3-1.3
ALF ^c worker	3.0	0.8-11.2		
Machine operator	1.0	0.7-1.4	0.9	0.6-1.4
Elementary worker	1.0	0.7-1.5	1.2	0.8-1.8
Industry				
Service	1.0	0.5-2.2	1.1	0.4-3.1
Manufacturing	1.1	0.8-1.7	0.9	0.6-1.5
Construction	1.0	0.7-1.4	1.1	0.7-1.7
ALF ^c	0.9	0.3-2.3		
Others	0.7	0.3-1.5	1.0	0.4-2.4
Injury Site				
Head & Neck	0.7	0.5-1.0*	0.7	0.5-1.0
Extremity	0.9	0.4-2.3	1.2	0.4-3.1
Trunk	0.9	0.5-1.5	0.9	0.5-1.6
Whole body	1.6	1.1-2.4*	1.6	1.1-2.4*
Year				
2007-2009	3.6	2.5-5.3**	3.5	2.3-5.3**
2010-2011	0.4	0.2-0.5**	0.4	0.2-0.6**
2012-2018	0.8	0.5-1.2	0.7	0.5-1.1
^a OR: Odds Ratio				
^b CI: Confidence Interval				
^c Agriculture, Livestock and Fisheries				
*p<0.05, **p<0.01				
Note: All adjusted odds ratios were from logistic regression adjusted for sex, age, occupation, industry.				

2.2.3. Factors associated with fatal occupational injuries

The FROI of Chinese migrant workers was significantly higher (1.22-fold, 95% CI 1.01-1.47) than that of Korean-Chinese migrant workers (Table 9) after controlling for the confounding effects of sex, age, occupation, and industry. We used the stepwise method to identify the best-fitting model and checked the goodness of fit using the Hosmer-Lemeshow test.

Table 9. Odds ratios for fatality of occupational Injuries between Korean-Chinese and Chinese migrant workers by models

Variables	Model1		Model2	
	OR ^a	95% CI ^b	OR ^a	95% CI ^b
Group				
Korean-Chinese	1.0	-	1.0	-
Chinese	1.2	1.1-1.5*	1.2	1.0-1.4
Sex				
Female	1.0	-	1.0	-
Male	2.8	2.0-4.0**	2.8	2.0-4.0**
Age				
15~28	1.0	-	1.0	-
29~36	1.5	0.9-2.6	1.5	0.9-2.6
37~44	1.5	0.9-2.6	1.5	0.9-2.5
45~53	2.0	1.2-3.4**	2.0	1.2-3.4**
54~81	2.4	1.4-4.0**	2.5	1.5-4.3**
Occupation				
Manager & Service worker	1.0	-	1.0	-
ALF ^c worker	.8	0.3-1.7	0.8	0.4-1.7
Machine operator	1.4	1.0-1.9*	1.4	1.0-1.9
Elementary worker	0.8	0.6-1.1	0.8	0.6-1.1
Industry				

Service	1.0	-	1.0	-
Manufacturing	1.1	0.7-1.7	1.1	0.7-1.6
Construction	2.4	1.6-3.7**	2.5	1.6-3.8**
ALF ^c	2.1	1.2-3.8**	2.0	1.1-3.5*
Others	1.3	0.8-2.1	1.3	0.8-2.0
Year				
2007-2009			1.0	-
2010-2011			0.7	0.6-0.9**
2012-2018			0.5	0.4-0.6**
^a OR: Odds Ratio				
^b CI: Confidence Interval				
^c Agriculture, Livestock and Fisheries				
*p<0.05, **p<0.01				
Note: Estimates were obtained by logistic regression adjusted for sex, age, occupation, and industry for model1.				

The FROI did not differ according to age until the mid-40s. Compared to subjects 15-28 years of age, the FROI of those 45-53 and 54-81 years of age was 2.02-fold (95% CI = 1.20-3.40) and 2.38-fold (95% CI = 1.42-3.99) higher. Thus, age \geq 45 years was a risk factor for fatal occupational injury. Machine operators had a significantly higher (1.37-fold, 95% CI 1.00-1.88) FROI than manager and service workers. The ORs of the construction (2.40) and ALF (2.13) industries were significantly higher using the service sector as the reference industry. Therefore, machine operator and the construction and ALF industries were associated with fatal occupational injuries among migrant workers.

2.3. Discussion

We evaluated factors associated with fatal occupational injuries among migrant workers in South Korea using data from 42,089 Chinese migrant workers from January 2007 to September 2018. The results showed that the prohibition on changing workplaces; male gender; age ≥ 45 years; machine operator; and the construction and agriculture, livestock, and fishery industries were risk factors for occupational injuries among migrant workers.

The meaning of high FROI can be explained in two ways. First, the higher severity of occupational injury. As Table 3 shows ‘whole body’ injuries are overwhelmingly fatal. Chinese migrant workers got a higher rate of whole body injuries and a higher FROI of the injury site according to Table 5. Second, limitation of the medical accessibility. It made difficult to identify differences in medical accessibility between two groups because that the data used does not show a legal status. However, since the change job without the permission changes the legal status and the status makes to forced deportation. From this reason, Chinese migrant workers are more likely to become undocumented migrants than Korean–Chinese migrant workers. At a high underreporting rate of occupational accidents, many migrant workers are treated with national health insurance. Undocumented migrants are not eligible for the health insurance, access to health care is restricted, which encourages delay or abandonment of medical treatments.

The FROI of Chinese migrant workers after controlling for the potential confounding effects of covariates was 1.22-fold higher than that of Korean–Chinese workers. The difference in FROI between the two groups was tied to our second research question, namely, identifying the risk factors of occupational fatal injury. The following

parameters need to be considered for comparison between the two groups: 1) Korean language proficiency, 2) the presence of family and relatives in South Korea, and 3) prohibition on changing workplaces.

First, the language barrier is not an important issue in South Korea because all migrant workers including Korean–Chinese migrant workers from EPS countries are required to score well on the official Employment Permit System–Test of Proficiency in Korean before beginning employment. Although Korean–Chinese have better language proficiency in Korean compared to Chinese migrant workers, Chinese migrant workers also achieve higher scores than those EPS workers from other regions (HRDKorea, 2018), which hampers reaching any conclusion on the impact of fluency in Korean on the incidence of fatal occupational injury. Moreover, prior studies on language barrier as a risk factor for occupational injury have reported inconsistent results (Pransky et al., 2002; Nuwayhid et al., 2003). Several studies from U.S and Gulf Cooperation Council countries found that language barrier was a risk factor (Tuma et al., 2013; Moyce & Schenker, 2018). In contrast, a study in Lebanon showed that 80% of fatally injured non–Lebanese workers spoke Arabic, the native language of that country (Nuwayhid et al., 2003). A study in South Korea suggested the lack of communication as one of the risk factors, not language proficiency because 80% of migrant workers were Korean–Chinese who were bilingual (Yi et al., 2012). The language barrier as a risk factor seems to vary depending on the recruiting system of migrant workers in different host countries. Lack of communication such as no or inaccurate work instructions rather than Korean language proficiency is a more reasonable factor associated with fatal occupational injuries in South Korea.

Second, the right to family reunification for migrant workers in South Korea is restricted. Korean–Chinese migrants obtained a labor visa only if they were invited by relatives resident in South Korea until 2007, and since then, they were granted the visa without an invitation. However, their visa still did not allow bringing their family. It is important to note that access to family support is not only a basic human right but also an important protective factor from occupational injury (Mekkoathil et al., 2016). Korean–Chinese migrant workers were not better than Chinese workers in this regard.

Therefore, the prohibition on changing workplaces, rather than language proficiency and access to family, likely explains the disparity in the incidence of fatal occupational injuries between Korean–Chinese and Chinese migrant workers. Additionally, the EPS, which deprives workers of a free choice of employment, had a greater deleterious impact on the fatality rate of occupational injuries to migrant workers than did the work permit system. South Korea has adopted a no–settlement principle for migrant workers, which includes a prohibition on changing workplaces. This could jeopardize the rights of migrant workers and impact their occupational health (Moyce & Schenker, 2018). Limiting the freedom to leave employment means that workers are thoroughly subordinate to their employers. The prohibition on changing workplaces has been criticized, and its abolition recommended, by the UN Committee on the Elimination of Racial Discrimination (CERD) (2008), the committee of experts of the International Labor Organization (ILO) (2014b), and the UN General Assembly–Human Rights Council (2015) for promoting forced labor and human trafficking. Despite this international criticism, the provision remains in place.

The prohibition on changing workplaces has a negative impact on the health of migrant workers, and its maintenance lacks a scientific basis. According to the precedent statement and the International Organization for Migration (IOM) report, the provision exists for economic reasons. The EPS was instituted to address manpower shortages at small and medium-sized enterprises, and the South Korean government accepted employers' claims that they would suffer from the wage hikes (Choi & Lee, 2015). However, Korean-Chinese migrant workers were able to change workplaces 1.27 times on average during their stay in South Korea, according to the 2015 policy report of the IOM Immigration Policy Research Institute, an UN migration agency established through a special relationship with the Korean government. Migrant workers tend to change workplaces to overcome complex issues, such as labor environment, labor intensity, or human relations, rather than to obtain an increased wage unless there is the prohibition (Choi & Lee, 2015). Financial status is not a major consideration when migrant workers decide to change workplaces. Therefore, abolition of the provision may not disrupt the labor supply or lead to continuous wage increases. Preventing injuries at work is economically and socially beneficial, as a country's gross national product may reduce up to 4% by occupational injuries and diseases (Wilson *et al.*, 2007). To reduce the incidence of occupational injuries, structural modifications, such as changing the provisions addressed in this study, are more effective than modification of workers' attitudes (Lund & Aarø, 2004).

Injured male migrant workers were more likely to die than injured female migrant workers. However, in South Korea, only workers who meet the criteria of the Labor Standards Law can claim

workers' compensation under the Korea Workers' Compensation Insurance Act. It is thus possible that some female migrant workers were unable to claim workers' compensation because they were not legally defined as workers. In the case of domestic workers, who perform domestic duties such as cleaning, cooking, and looking after children or elderly people (UNAOC, 2014), the overwhelming majority was female and 92.8% were classified as self-employed; i.e., not legal workers (Hwang, 2015). Male gender is reportedly a risk factor for migrant workers, but there are marked disparities in mental health outcomes, cancer rates, occupational injuries, and reproductive health outcomes between male and female workers (Moyce & Schenker, 2018). Females comprise only 8.8% of non-professional migrant workers in South Korea, but 40.4% of all migrant workers of Korean descent (Korean Immigration Service, 2018). The different employment patterns of female and male migrant workers may result in their facing different occupational hazards.

Age ≥ 45 years was a risk factor for fatal occupational injuries among migrant workers, as reported previously (Pransky et al., 2002; Mekkodathil et al., 2016). In contrast, older native workers in the US had a low injury rate. This was attributed to the healthy worker effect, whereby older workers retire from high-risk jobs or move to less demanding jobs (Arrighi & Hertz-Picciotto, 1994). However, the effect seems not for older migrant workers who may need to remain in high-risk occupations (Pransky et al., 2002; Ahonen & Benavides, 2006).

Machine operator was the highest-risk occupation, and construction and ALF were the most physically demanding industries. Only machine operator had a significantly high risk of occupational

injury, using manager and service workers as the reference. Construction and ALF were risk factors for fatal occupational injuries, consistent with previous reports (Cha & Cho, 2014; Al-Thani et al., 2015). The ALF industry had a high FROI but few (n = 26) fatalities, suggesting that ALF workers could not claim workers' compensation unless they were severely injured.

This study has several limitations. First, those who are not legally defined as workers according to Korean Law have been omitted from the data of workers' compensation claims, thus further studies that include such workers are needed. Second, the occupational categories may have been inaccurate. The colleagues or agents who reported deaths may have misclassified the occupation of the deceased (Son, 2001). Even with these limitations, we used FROI as the dependent variable because workers' compensation data on fatal occupational injuries provide reliable information about occupational deaths (Stout & Bell, 1991; Rossignol & Rossignol, 1993) and mortality data are the most reliable measure when underreporting rates are high.

A longitudinal follow-up study of the health of migrant workers is needed to ascertain whether the prohibition on changing workplaces affects not only occupational injuries but also occupational diseases. Because this was an observational cross-sectional study, we could not control for missing or unmeasured factors, and were unable to establish causality. The importance of this study lies in its comparison of recruitment systems and it being the first investigation of the effect of the prohibition on migrant workers changing workplaces on fatal occupational injuries.

Overall Conclusions

This study aimed comparing OSH of migrant workers and native workers in each Asian countries in chapter 1. Despite the increase in the number of migrant workers, the number of studies concerning OSH among Asian migrant workers who migrated to Asia is extremely small and the diversity of countries is very limited. The study results showed migrant workers from Asia migrating to Asia had higher fatality rates due to occupational injury than the native workers' in the destination country. As shown in the construction industry, which has the highest risk of death due to occupational injury, and many migrant workers who work there, the industry of migrant workers is being separated. In addition to, riskier jobs were designated to migrant workers in the same industry, the most frequent death mechanism for the workers was fall from height.

Chapter 2 of this study aimed to determine whether the FROI differs between Korean-Chinese and Chinese migrant workers and identified the risk factors for fatal occupational injuries among migrant workers in South Korea. The data revealed the prohibition on changing workplaces to be a risk factor for fatal occupational injury. Additionally, male gender; age ≥ 45 years; machine operator; construction; and agriculture, livestock, and fishery industries were associated with fatal occupational injuries among migrant workers in South Korea.

Since the previous studies on the OSH of migrant workers were centered on high - income countries, this study focusing on Asian countries is meaningful as the first systemic literature review.

As a result, migrant workers who had moved to Asian countries, as was known by studies in the U.S. and Western European countries, also had a worse OSH than native workers in each Asian countries. Studies from countries that cite OSH has improved for native workers based on rate of occupational injuries or fatalities suggests that migrant workers have opposite pattern of their counterparts' OSH. It is more plausible to interpret that this is not the rise of the level of OSH in a country but the workers with riskier jobs are changed from native to migrant workers without changing the poor working environment. Migrant workers are inferior to native workers in terms of health equity, moreover they have not equitable OSH among migrant workers by EPS. South Korea needs to urgent countermeasures to lower occupational fatality rate with the increasing number of migrant workers. Policies to improve recruiting system for migrant workers and to strengthen workplace safety measures are the responsibility of the governments and businesses. Ultimately, preventing occupational injuries to migrant workers in high-risk occupations will improve the health of all workers.

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- (# mark is the article included in this systematic review)

Appendix

Table A. 1. Searching results by databases

Database	Searching strategy	Time	Number
Pubmed	((((injury[Title/Abstract] OR accident*[Title/Abstract] OR unnatural death)[Title/Abstract])) AND ((migrant* OR immigrant OR foreign) AND (occupation OR work OR works OR worker OR workers OR occupational OR labor OR labour OR industrial) AND (death OR fatality OR mortality)))	20180418 18:00	349
Science Direct	((migrant* OR immigrant OR foreign) AND (occupation OR work OR works OR worker OR workers OR occupational OR labor OR labour OR industrial) AND (death OR fatality OR mortality) AND tak(injury OR accident* OR unnatural death))	20180418 17:57	1,266
MEDLINE	((migrant* OR immigrant OR foreign) AND (occupation OR work OR works OR worker OR workers OR occupational OR labor OR labour OR industrial) AND (death OR fatality OR mortality) AND AB,TI(injury OR accident* OR unnatural death))	20180418 17:56	131
EMBASE	('injury':ab,ti OR 'accident*':ab,ti OR 'unnatural death':ab,ti) AND (migrant* OR immigrant OR foreign) AND (occupation OR work OR works OR worker OR workers OR occupational OR labor OR labour OR industrial) AND (death OR fatality OR mortality)	20180418 17:50	146

Table A. 2. Full-text articles excluded with reasons

[exclusion reasons]

- ① Adult(18years old or older) international Asian migrant workers who move to Asia only
- ② Article only
- ③ Non-fatal occupational injury only
- ④ No fatal occupational injury included
- ⑤ Duplicate
- ⑥ English only
- ⑦ No full text available

Citation [APA style]	Reason
AL-Abdallat EM, Oqailan AMA, Al Ali R, Hudaib AA, Salameh GAM. Occupational fatalities in Jordan. 2015;29:25-9.	1
Al-Thani, H., El-Menyar, A., Consunji, R., Mekkodathil, A., Peralta, R., Allen, K. A., & Hyder, A. A. (2015). Epidemiology of occupational injuries by nationality in Qatar: Evidence for focused occupational safety programmes. <i>Injury</i> , 46(9), 1806-1813.	5
Al-Thani, H., El-Menyar, A., Abdelrahman, H., Zarour, A., Consunji, R., Peralta, R., . . . Latifi, R. (2014). Workplace-related traumatic injuries: insights from a rapidly developing Middle Eastern country. <i>J Environ Public Health</i> , 2014, 430832.	3
Allen KA, Hyder A, Robinson W. Quantifying the burden of injuries in temporary labour migrants: an analysis	1

from the United Arab Emirates. Consortium of Universities for Global Health, 6th annual conference. 2015;3:S32-.	
Aryal N, Regmi PR, van Teijlingen E, Simkhada P, Adhikary P, Bhatta YKD, et al. Injury and Mortality in Young Nepalese Migrant Workers: A Call for Public Health Action. <i>Asia-Pacific journal of public health.</i> 2016;28(8):703-5.	3
Barss, P., Addley, K., Grivna, M., Stanculescu, C., & Abu-Zidan, F. (2009). Occupational injury in the United Arab Emirates: epidemiology and prevention. <i>Occupational medicine</i> , 59(7), 493-498."	3
Bollini, P., & Siem, H. (1995). No real progress towards equity: health of migrants and ethnic minorities on the eve of the year 2000. <i>Social science & medicine</i> , 41(6), 819-828.	3
Bong, A., Chao, T. C., & Lee, J. (1976). Risks of death from industrial accidents of foreign workers in Singapore. <i>Annals of the Academy of Medicine Singapore</i> , 5(2), 138-142.	7
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국문초록

한국 내 중국 이주노동자의 업무상 치명상 위험요인

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본 연구는 이주노동자의 노동안전건강(Occupational Safety and Health)을 크게 두 부분으로 나누어 연구했다. 제1장에서는 아시아 국가에서 국제 이주한 성인 이주노동자의 업무상 치명상 정도를 도착국 정주노동자와 비교하고, 치명률이 높은 업종과 주된 사망의 메커니즘을 살폈다. 아시아 국가를 이주의 도착국으로 한 첫 번째 체계적 문헌고찰로 의미가 있는 본 연구는, 출판 연도에 제한을 두지 않고 2018년 4월 18일까지 영어로 출간된 모든 연구를 검색하였다. Pubmed, Science Direct, MEDLINE, EMBASE 데이터베이스를 이용해 아시아 국가로 이주한 아시아 출신 성인 노동자의 업무상 사망을 정량적으로 표현한 연구는 모두 포함하였다. 그 결과 싱가포르, 한국, 카타르의 네 개 연구만이 포함되었는데, 모두 각국의 이주노동자가 정주노동자에 비해 업무상 손상률 또는 업무상 치명률이 유의하게 높다고 보고하고 있다. 또한 각국의 이주노동자는 높은 비율로 남성 노동자이고 건설 노동자이며 주된 사망 메커니즘은 추락임을 확인하였다.

제2장은 한국으로 범위를 좁혀 이주노동자의 업무상 치명상 위험요인을 알아보았다. 이주노동자 건강 연구에서 한국의 특수함은 다음 두 가지에서 찾을 수 있다. 첫째, 업무상 손상과 질병의 주요 위험요인으로 알려진 이주 비용을 낮추는 것만으로는 이주노동자의 노동안전건강 결과를 향상시키지 못함을 보여 준다. 둘째, 고용허가제라는 하나의 제도 아래 실질적으로 취업허가(특례)와 고

용허가(일반)라는 두 개의 제도를 운용하기 때문에 두 제도를 비교할 수 있다는 점이다.

본 연구는 국가 자료인 근로복지공단의 2007년부터 2018년 9월까지 한국 내 이주노동자의 산업재해보상 신청 자료를 사망을 기준으로 단면 연구한 것이다. 두 제도에 따른 이주노동자의 업무상 치명률을 결과변수로 하여 비교해보고자, 언어와 문화를 공유한 중국 국적 이주노동자의 승인된 업무상 손상 자료 42,089건을 로지스틱 회귀분석했다. 그 결과 고용허가와 취업허가를 받는 두 집단 중 취업허가만 필요한 집단을 기준으로 하였을 때, 고용허가가 필요한 집단이 손상 중증도가 높은 복합 손상을 포함한 전신 손상의 비율이 커 업무상 치명률이 통계적으로 유의하게 높은 것을 확인할 수 있었다 (1.22배, 95% 신뢰구간 1.01~1.47). 각 제도에 따른 두 집단의 가장 큰 차이점은 한국어 사용 능력 정도, 한국에 연고가 있는지, 사업장이동 가능 여부를 고려할 수 있는데, 본 연구는 그중 업무상 치명률 차이를 사업장이동 가능 여부에 따른 결과라고 해석하는 것이 가장 타당함을 설명한다. 공변량으로 연도, 성별, 연령, 직종, 업종을 분석하였는데, 그중 연도 구분에 따른 두 집단의 치명률 경향 차이는 사업장이동 가능 여부가 업무상 치명상 위험요인 중 하나라는 사실을 뒷받침한다. 또한 남성이라는 젠더, 45세 이상의 연령, 기계 조작자, 업종으로써의 건설업과 농축산어업은 한국 내 중국 국적 이주노동자의 업무상 치명상 위험 요인이었다.

전 세계적으로 정주노동자 보다 열악한 노동안전건강을 보이는 이주노동자 집단은, 해당 집단 안에서도 적용 제도에 따라 층위가 나뉘는 본 연구로 알 수 있었다. 한 집단이 구조적 요인에 의해 업무상 치명상 가능성이 높다는 사실은, 노동자 개인의 불행임은 물론 이주의 출발국 및 도착국 모두의 사회적, 경제적 손실임과 동시에 보건 형평성에 어긋나는 일이다. 한국을 비롯해 이주노동자의 수가 증가하고 있는 세계 각국이 새로운 이주노동자 모집 체계를 모색하고 위험요인을 통제할 방법을 찾아 모든 노동자들이 안전한 환경에서 건강하게 노동할 수 있게 만드는 데 모쪼록 본 연구가 참고가 될 수 있길 바란다.

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주요어 : 이주노동자, 위험요인, 사업장이동, 업무상 손상, 치명률, 노동안전건강
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