Health deterioration caused by irregular working schedules

--A Case Study on Railway Workers in Southwest China

Rachel Li (s2606925)

Department of Health Science,

Master Thesis

University of Twente

Supervisor: Prof. Dr M.D.T de Jong (Menno), Department of Communication Science, University of Twente

Second supervisor: Prof. Dr Shawn Donnelly, Department of Health Science, University of Twente

Contents

List of Tables

List of Figures

Health deterioration caused by irregular working schedules

--A Case Study on Railway Workers in Southwest China

Abstract

Purpose: This study investigates the most common work-related diseases of railway workers in Southwest China and tries to build some mediation analysis models to elucidate the effects of irregular working schedules, including unhealthy lifestyles (smoking, drinking) and work-related diseases.

Methods: This study used a secondary analysis of an existing non-public dataset with passed ethical approval from the Sichuan University of China. The dataset collects the health examination results of China Railway Chengdu Group Co., Ltd 23265 employees. The health situation among railway workers in Southwest China was analysed statistically by descriptive analyses, Chi-squares and mediation analyses.

Results: According to the descriptive analyses, the most common diseases of railway workers are endocrine, nutritional and metabolite diseases, circulatory system diseases, digestive system diseases, blood diseases. The results show that the number of endocrines, nutritional and metabolite disease is the most. We have confirmed through mediation analysis that shift work is a higher weighted factor that causes workers to get sick among these four work-related diseases. Smoking and drinking played an intermediary role in the model.

Conclusion: Irregular working schedules not only directly lead to work-related diseases but also cause workers to choose some unhealthy lifestyles, such as smoking and drinking, which can also lead to work-related diseases. This study provided a research foundation for future scholars and health decision-makers in occupational health to have some detailed research on each disease or make relevant health decisions based on the current results.

1. Introduction

1.1 Background

Due to the production needs, workers are facing heavy workloads and long working hours. On average, people who are engaged in work spend one-third of their time at the workplace. Occupational diseases and work-related disorders claim the lives of 2.3 million individuals worldwide each year. Among them, occupational diseases lead to 318,000 deaths, work-related diseases lead to 202,000 deaths. 32% of the pathogenic factors are work-related cancers, 23% are work-related circulatory disorders, cardiovascular diseases and strokes, 17% are infectious diseases (Takala et al., 2014). Thus, more and more people have health problems or even death due to their heavily loaded jobs.

By 2012, China's total railway mileage will reach 97,625 kilometres, and it is expected to exceed 10,000 kilometres by 2020. It will have the highest railway transportation density globally (39.95 million equivalent ton-kilometres/km in 2012). There are approximately 2 million railway workers in China (Jiang et al., 2020). The health of these railway workers has a direct economic impact on the railway industry. A recent report showed that more than a million working days are lost for railway workers due to sickness each year, and the railway industry also suffered substantial economic losses (Office of Rail and Road, 2019). An industrial report is estimated that the total annual cost of new cases due to the current working

conditions of railway workers is between 10 million and 20 million pounds (Health and Safety Executive, 2018). This shows railway workers health problems involve a large number of people and may affect the economy. Therefore, the health of railway workers should be taken seriously.

Shift work is an occupational characteristic of workers in the railway transportation industry. It will harm the people's intrinsic clock and cause many adverse effects on health, such as getting circulatory system and digestive system diseases (Zhang et al., 2016). At present, European and American countries have paid more attention to occupational health, and there have been many studies on shift work. Their research mainly focuses on the effects of shifts on the intrinsic clock, chronic diseases and health conditions. The research scope is broad, and the research content is detailed. China has issued some measures to prevent occupational diseases and work-related diseases, such as Measures for the Administration of Occupational Health Examination and Measures for the Supervision and Administration of Employers' Occupational Health Surveillance. Nevertheless, the awareness of how shift work has affected health has still not been raised, and they only have a few studies on shift work, and the sample size is small. So in this study, we will focus on how shift work affects the health of the railway workers in the South-west of China (Cheng, 2011).

1.2 Research Gaps

Knowledge gap 1 on causality analysis

The past researches mainly focused on one-way causation analyses, which were used to analyse the impact of a specific exposure environment of railway workers, such as noise, dust, and shock exposure. These studies usually only consider one influencing factor, summarise the work-related diseases through descriptive, and find out the single relationship between the diseases and specific exposure environment. For example, research from Johanning said that in North America, maintenance workers constructing railroad tracks use specialised electric hand tools, which results in exposure to vibrations transmitted by hand. Regularly exposure to hand-arm vibration (HAV) is recognised as a causal factor for musculoskeletal and neurovascular disorders (Johanning et al., 2020). According to a study from Japan, the railway workers exposed to asbestos have a high chance of getting pleural plaques, malignancies, and pneumoconiosis (Hosoda et al., 2008). In Lie et al.'s study, he claimed that railway workers engaged in train and track maintenance might be at risk of hearing loss because they are often exposed to noise levels of 75-90 decibels and may be exposed to peaks of 130-140 decibels noise level (Lie et al., 2014).

In our study, we will expand our study area and use multiple causation analyses to analyse the factors that affect the health of railway workers.

Knowledge gap 2 on analysis of irregular schedule

Railway workers have a chaotic working schedule. Unlike other shift working jobs with a relatively fixed day shift or night shift, most railway workers' work and rest time are mainly affected by the train schedules. From a previous systematic review, we can infer that China's vast land and long railway routes always take many days for a train to return to the place of departure. During this period, the train staff had to turn upside down day and night, which led to the intrinsic clock of these workers being wholly disrupted. Such a long-term intrinsic clock disorder makes workers more likely to suffer from different kinds of work-related diseases. However, there has not been any research on the impact of the chaotic intrinsic clock on the

physical health of railway workers (train drivers, train attendants) in Southwest China. Existing research only focused on the implications of chaotic intrinsic clocks on railway workers' mental health.

In conclusion, research in the railway workers area lacks a comprehensive understanding of railway workers' health issues. These gaps also make it challenging to propose evidence-based strategies, interventions, and policies for health management and promotion among this vulnerable population. The health problem caused by the shift work has appeared in lots of railway workers, and it will appear in more and more people as time passes, if not controlled, finally will become a significant public health problem in the future. Nevertheless, research about the effects on health caused by shift work on railway workers is lacking nowadays. The two reasons above raised our interest to do the following study.

1.3 Research Questions

To fully understand the health of railway workers, researchers and health planners must understand and analyse the common work-related diseases and the relationship between the risk factors. The specific research questions are illustrated in the following sections.

This study talks about the health problems of railway workers and the relationship of the risk factors. We will give related suggestions about health management strategies, interventions, and policies. This study tries to answer the research questions: (1) What work-related diseases do Southwest Chinese railway workers have? (2) What are the relationships between the risk factors (irregular working schedule, smoking, drinking) and work-related diseases?

Question 1: What work-related diseases do Southwest Chinese railway workers have?

After sorting the positive results, the top-ranked work-related diseases have more than 2000 cases, while the bottom-ranked diseases have only less than 500 cases. The top-ranked work-related diseases were chosen for this study because these work-related diseases are more common among railway workers. By analysing work-related diseases with top-ranked, our suggestion can more targeted health management.

Question 2: What is the relationship between immediate risk factors (working irregular), potential risk factors (smoking, drinking) and work-related diseases?

There are so many risk factors that can affect the health of the railway workers, such as past medical history, family history, working schedules, diet habits, smoking, drinking. This study will focus on working schedules, smoking, and drinking to figure out their relationship.

1.4 Research Objectives

Our study is proposed to find out the most common work-related health problem in railway workers. Moreover, we proposed to use mediation analyses to know the relationships between the risk factors and work-related diseases.

Our results will provide reliable work-related diseases information about Southwest China and lead to a better understanding of work-related diseases from their causing aspect to their terrible health consequences. It is conducive to providing functional theoretical and practical policy implications for work-related health management.

2. Literature Review

Work-related health problems can be divided into work-related diseases and occupational diseases. “Work-related diseases” are caused or aggravated by factors in the workplace, which includes many diseases with more complex etiologies involving occupational and non-work-related factors. “Occupational diseases” refer to conditions that are mainly caused by exposure to physical, organisational, chemical, or biological risk factors or a combination of these factors at work (European Commission, 2003). According to the International Labor Organization (ILO), the economic losses of work-related diseases and occupational diseases account for 4% of the gross domestic product (GDP) of member countries (Gupta et al., 2017). Thus, out of consideration for the entire economy, work-related health problems should be paid attention to from a macro perspective.

Today, work-related diseases are becoming more and more critical. Long-term latent occupational diseases continue to increase, and it is leading to complications such as lung cancer and circulatory system diseases. Moreover, long-term medical care for workers who have musculoskeletal disorders and psychosocial factors is lacking. A study talked about the contemporary world of work also shows that the work organisation itself can affect psychological stress’s levels experienced by workers and may increase health problems related to occupational hazard exposure, such as musculoskeletal diseases, cardiovascular diseases, metabolic syndrome, and diabetes, or leading to injury or illness (Iavicoli et al., 2018).

2.1 Working irregular and its effects on health

The development of train transport exacted a high toll on human lives and health (Jairo-Ernesto, 2020). Currently, most of the research results about Chinese railway workers’ health status is based on the physical examinations of the railway workers; and the majority of studies revealed that railway workers’ physical health is not promising. Zhang’s research summarised that endocrine, metabolic and cardiovascular (abnormal electrocardiogram, hypertension, hyperglycemia, hyperlipidemia, etc.) are the most common diseases found in railway workers (Zhang et al., 2016). Also, Kolmodin’s research about the Swedish railway worker found out that the railway worker has a higher probability of getting digestive system diseases than the general population (Kolmodin-Hedman & Swensson, 1975). Last but not least, Jiang’s research showed that employees who work in the transportation industry have a higher rate of having physical health issues than other occupations, including those in the professional and management occupations (Jiang et al., 2020).

Railway workers are a group of people who work for the railway system, such as train drivers, railway maintenance workers, and railway station dispatchers. The railway system operates 24 hours a day, 7 days a week, employees in most departments in the system face the problem of shift work. Irregular working schedules have a direct impact on work-related diseases. Due to the 24-hour uninterrupted operation of the railway system, most railway workers are faced with the need to shift work or night work to meet their work needs. Such irregular working schedules will continue throughout their careers. Irregular working hours broke the intrinsic clock and caused health problems, such as a drop in sleep time and quality. Furthermore, with irregular working schedules, workers may choose unhealthy lifestyles such as consuming tobacco and drinking alcohol. These unhealthy living styles will indirectly result in work-related diseases.

2.1.1 The direct impact of the irregular working schedule on health

The most significant health hazard to railway workers is the health problems caused by the shift work, which causes an irregular intrinsic clock (Fan & Smith, 2020). Especially night shifts and morning shifts can disrupt the sleep-wake cycle, deprive workers of sleep, and ultimately lead to health problems. Railway operation workers' working places are always unstable and change with the train. Railway schedules are variable and unpredictable since the operational schedule changes with the train time, and the day and night are reversed. Train timetables and work schedules depend on many factors, including market demand and availability, weather, accidents, et al. Such irregular working hours usually accompany the entire career of a railway worker (Paterson et al., 2012). Teams of drivers and train attendants need to work and sleep on direct trains between the origin and destination cities. Even though there are specially designed rest carriages for workers on the train to provide rest space for non-working hours, investigations show that the quality of rest for drivers and train attendants is deficient. A study shows that, due to the irregular working schedule and poor rest environment, the average rest time for drivers and train attendants is only 4.0 hours and 3.3 hours of sleep per day (Hosoda et al., 2008). Therefore, railway workers cannot get enough sleep when they work to follow the train.

Compared to the other type of work's regular shift work schedule, which start to work at the same time every day, such as doctor or nurse, the schedule of railway workers rotates irregularly. They have been divided into rapid changes with multiple weekly plans and slow modifications (for example, multiple weeks for each method). Other common shift alternatives include split shifting (that is, working at night during certain hours) and irregular shifts in which employees' working hours are unpredictable (Wickwire et al., 2017). Such rotating schedules also make the work and rest of workers often change irregular. Not only the sleep-wake cycle is disrupted, drivers and train attendants also face shifts working long hours. Depending on work needs, people should face 12-hour or even 24-hour shifts. A survey of more than 1.2 million cases in Germany also shows that the risk of health problems occurring during working hours of more than 8 hours has increased exponentially, especially when the start time is not the regular day shift (9 a.m.). Moreover, as the number of shifts increases, the ability to cope with lack of sleep or working overnight will further deteriorate (Costa, 2010).

Shift work disrupts the sleep-wake cycle, causing drowsiness, fatigue, and impaired performance. The long-term sleep-wake process disrupted will affect the intrinsic clock, which finally will affect the health of railway workers and cause health inequality. The intrinsic clock determines the sleep-wake process and cognitive functions (learning and memory). Circadian disruption can lead to sleep disorders, psychiatric, neurodegenerative diseases, cancer, infection, inflammation, cardiovascular disease, endocrine and metabolic diseases (Allada & Bass, 2021).

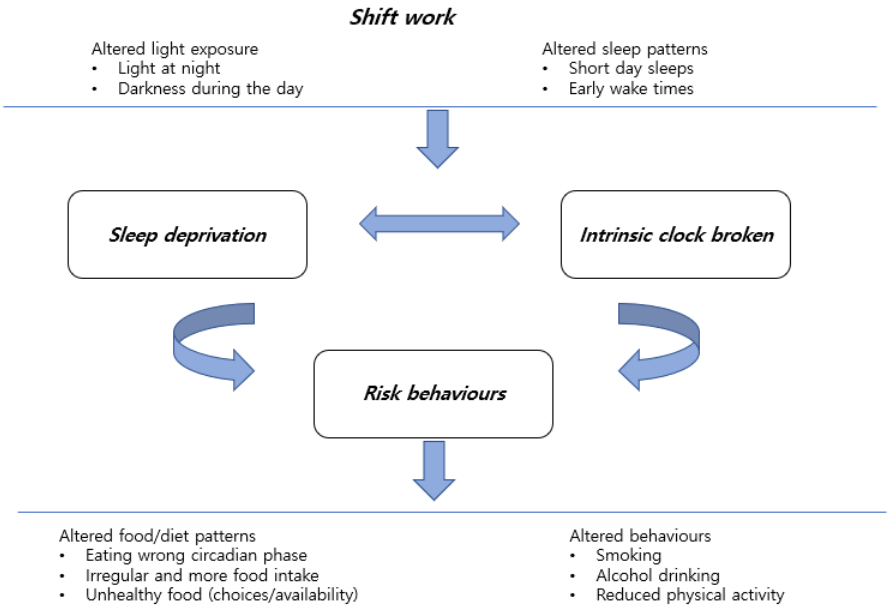
2.1.2 The indirect impact of the irregular working schedule on health

Several recent reviews have dealt with possible mechanisms by which shifts are detrimental to health. People with shift work may experience light exposure (light at night, darkness during the day) and altered sleep patterns (shorty day sleeps, early wake times). Shift-related behaviours lead to sleep deprivation, intrinsic clock destruction, and other behaviours. These will change the diet and behaviour patterns of people. The change includes changes in eating habits, such as irregular and more food intake, eating wrong circadian phase, unhealthy food intake. And changes in behaviour habits, such as smoking, alcohol drinking and reduced

physical activity (Kecklund & Axelsson, 2016). Figure 1 summarises these mechanisms, which model changes in diet and behaviour patterns caused by shift work.

Figure 1

Model of Changes in Diet and Behaviour Patterns Caused by Shift Work



Lowden et al.'s recent narrative literature review showed that shift work causes unhealthy eating habits, such as irregular eating, eating at the wrong time, and poor food quality. Despite the fact that night shift workers' total energy intake is equivalent to day shift workers, there is evidence that they consume more carbohydrates (associated with snacking) and less fruit. (Lowden et al., 2010). Three studies from Puttonen, Vandelanotte, and Härmä et al. reported that shift workers smoke cigarettes more frequently due to work reasons and engage in less physical activities (Puttonen et al., 2010, Vandelanotte et al., 2015, Harma, 2006). Furthermore, a recent meta-analysis found that, as compared to the usual 35-40 hours of shift work per week, working longer hours, such as more than 48 hours per week, may increase alcohol use (odds ratio 1.12) (Virtanen et al., 2015). Such unhealthy lifestyles could finally lead to diseases.

(1) Smoking

Smoking can affect endocrine and metabolism and lead to endocrine and metabolic diseases, including diabetes, insulin resistance, and thyroid disease. Also, smoking can cause infertility, many different skin diseases and gastrointestinal diseases, such as peptic ulcer disease, gastroesophageal reflux disease and inflammatory bowel disease (Mallampalli & Guntupalli, 2004). Smoking directly or indirectly affects the digestive organs and induces benign and malignant diseases of the digestive tract (Tsujii et al., 2013).

Moreover, smoking is one of the leading causes of coronary heart disease worldwide (Huxley & Woodward, 2011). Tobacco smoke is one of the main risks of thrombosis, sudden cardiac death, atherosclerosis, increased acute myocardial infarction, aortic aneurysm, stroke, and peripheral vascular disease. Acute myocardial infarction is increased by even extremely low-dose exposures. (Bullen, 2008).

(2) Alcohol drinking

Ethanol has direct toxicological effects because it interferes with liver metabolism and immune function (Anyanwu & Watson, 1997). Excessive drinking is the leading cause of chronic liver disease because alcohol can cause simple steatosis into many liver diseases such as steatohepatitis, liver fibrosis, cirrhosis and hepatocellular carcinoma (HCC) (Wang et al., 2019).

Alcohol drinking was significantly and positively associated with high blood pressure (BP) and high triglyceride (TG) (Park et al., 2015). Regular drinking can cause blood pressure to rise, and the global estimated risk of alcohol-induced hypertension is 16%. Cerebral thrombosis, cerebral haemorrhage and coronary artery disease are related to heavy drinking (Puddey & Beilin, 2006). Carrino's study shows that alcohol drinking can damage the blood-brain barrier (BBB), alcoholism and finally induce neuroinflammation and neurodegeneration, leading to brain damage (Carrino et al., 2021). Alcohol also has many pathological effects on hematopoiesis. Since ethanol also interferes with platelet function, prolonged bleeding time is typical in all stages of alcoholism. In addition, long-term alcohol intake can lead to various types of hemolytic anaemia (Scharf & Aul, 1988).

In conclusion, studies have proven that workers will choose unhealthy lifestyles due to shifting work, such as drinking, smoking, and bad eating habits. Furthermore, these unhealthy lifestyles can cause or aggravate some health problems. Some workers choose to smoke or overeat to relieve fatigue and loneliness at work. Studies have shown that irregular shifts cause some workers to suffer from sleep disorders. Sleep disorders are characterised by difficulty falling asleep, a long time to fall asleep, and poor sleep quality. To overcome these problems, workers often resort to some drugs or food with hypnotic ingredients. It just happens that alcohol is the easiest thing to get, which helps them get into sleep easier. That is why some long-term irregular workers have alcoholism(Cheng & Drake, 2019). Furthermore, this may exhibit unhealthy behaviours due to shifting work, leading to health hazards.

3. Methods

3.1 Data description

This research involves a secondary analysis of an existing non-public dataset from Sichuan University of China. Since the cooperation between the Sichuan University and China Railway Chengdu Group Co., Ltd, we got approval from Sichuan University to use this dataset with passed ethical approval. Chengdu Railway Administration, located in Southwest China, is a subsidiaries company under the jurisdiction of the China Railway. It oversees 9 primary railway routes, with an operating length of 6154.4 kilometres. This dataset can represent the health of all railway workers in the entire southwestern region because the Chengdu Railway system is the largest railway hub in Southwest China, covers almost all places in the southwest region. Therefore, the health status of this sample can represent the health status of the entire railway population in the southwest region.

This research recorded the health examination result for 23265 employees from Chengdu Railway Administration in 2020. Besides collecting laboratory testing and physical examination data, the local health examination centre did the primary information survey and assessed cigarette smoking and alcohol consumption. They designed the questionnaire, collected the data, and sent the final health examination report to us. This physical examination is not only targeted at occupational diseases because this physical examination aims to understand the physical condition of the workers and carry out general screening for all

diseases rather than specialised occupational disease examinations. According to the health survey and health assessment, we know that the risk factors are working schedule, smoking history, and drinking history.

Working irregularly in this study refers to any sort of shift work in which workers operate in the same workstation according to a defined model or rotational mode, which might be continuous or discontinuous. Sometimes workers need to work at different points in a given time period. People with a smoking history refer to current having cigarette smoking behaviour or quitting cigarette behaviour less than six months. People with a drinking history refer to current alcohol drinking behaviour or quit alcohol drinking less than six months.

3.2 Data collection

Chengdu Railway Administration arranges health examinations for all employees every year (except temporary employees). It entrusts the local health examination centres in Sichuan, Chongqing, and Guizhou to provide health examinations for employees and collect all the results. The health examination contents include blood routine, urine routine, physical examination, surgical examination, ophthalmic testing, chest radiography, thyroid ultrasonography, abdominal ultrasonography, electrocardiography, etc. Meanwhile, the health examination centre also collected all employees' smoking and drinking histories through health questionnaires. The questionnaire about smoking includes the frequency of smoking, the number of cigarettes smoked per day, and the years of smoking. The drinking questionnaire also includes the type of alcohol, the frequency of alcohol consumption, the amount of alcohol consumed each time, and the years of alcohol consumption. The informed consent of all participants was obtained before data collection. We anonymise all physical examination results and questionnaires and only collect the personal information needed for research. Participants are assured that all information provided in the questionnaire will be kept confidential.

3.3 Samples

23265 people participated in the health examination between July and November 2020, among 735 female cases (3%) and 22430 male cases (97%). The sample population includes all kinds of people that work in the railway system, such as dispatchers (1.2%), administration staff (7.1%), train attendants (7.9%), train drivers (39.3%), and workers who rotate maintain track, electricity, and fuel systems 24 hours a day (45.5%). Among the sample population, the average age of the total sample is 40.2, ranging from 19 to 65. There are 6757 people (29%) aged 19-29, 3302 people (14%) aged 30-39, 7841 people (33.9%) in the age of 40-49, 5336 people (23%) aged 50-59 and 29 (0.1%) people between 60-65. Moreover, 7609 participants (33%) were working irregular.

3.4 Statistical analysis

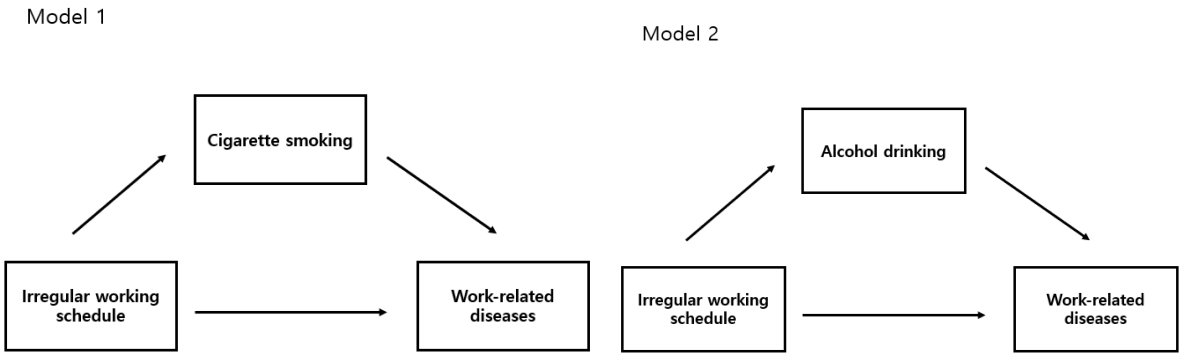
Mediation analysis proposes a series of relationships in which the leading variable will affect the mediating variable, which will affect the outcome variable. Mediating variables are behaviour, biological, psychological, or social structures that transfer the influence of one variable to another variable. Researchers can use this technique of study to illustrate the process or mechanism by which one variable influences another. (MacKinnon et al., 2007). The intermediate variable (M) is an intermediary. It acts as a "mediator" between predictor X and the outcome, following the basic mediation analysis steps suggested by Baron and Kenny (Baron & Kenny, 1986). This analysis includes three sets of regression: $X \rightarrow Y$, $X \rightarrow M$, and

X + M → Y. In the beginning, this analyses method was mainly used in psychological theory and research. But, with the development of various disciplines, scholars have gradually used it in occupational health research (MacKinnon et al., 2007). For example, Plotnikoff and other researchers used longitudinal mediation analysis to figure out the role of self-efficacy on the relationship between the workplace environment and physical activity (Plotnikoff et al., 2010). Some examples from the Scandinavian Journal of Work Environment showed that the mediating role of well-being on the relationship between office type and job satisfaction (Otterbring et al., 2018). Moreover, through mediation analysis, Jensen and other scholars examined whether workplace social capital contributes to the association between organisational change and employee turnover (Jensen et al., 2019). With all the examples above, we concluded that the mediation analysis could also be used in the occupational health research area, and this can give us a base of our theoretical analysis.

This study plans to use mediation analysis to find the relationship between working irregulars, smoking, drinking, and work-related diseases. Data were analysed using SPSS statistical package version 26.0 (IBM, Armonk, NY, USA). We use descriptives to summary the most common work-related diseases of the railway workers in Southwest China. Chi-square was used to find out the relation between the prevalence of work-related diseases and workers characterises. Considering cigarette smoking and alcohol drinking may be caused by irregular working schedules, and finally, result in work-related diseases. We tried to use mediation analysis to explain the relationship between the irregular working schedule and cigarette smoking, alcohol drinking and work-related diseases. According to three sets of regression of medication analysis, we tried to build two practical models (Figure 2) to suit this study. Regarding irregular working schedule as an independent variable, disease as a dependent variable, and introducing the smoking history and drinking history as intermediary variables, the theoretical models suit for this study are constructed as follows:

Figure 2

The Practical Models used in this study



**These models are based on the mediation analysis model*

Following the model we built, we tried to determine the relationship between irregular working schedules, cigarette smoking, alcohol drinking and work-related diseases through four steps. The four steps of the classic technique, based on three regression equations, are used to see if a prospective mediator has an impact on the relationship between the predictor and the dependent variable. (Plotnikoff et al., 2010).

Spearman correlation is the first step in mediation analysis to know the correlation between age, irregular working schedule, drinking, smoking, and diseases. According to the theory of Baron and Kenny, there are three rules that we need to follow. First, the independent variable (working irregularly) must be related to the dependent variable in a significant way (work-related diseases). Second, the independent variable should always be related to the potential mediator in a substantial way (drinking and smoking). Finally, the potential mediator must have a strong relationship with the dependent variable.

Multiple hierarchical regression analysis of irregular working schedules and drinking and smoking is the second step of the mediation analysis to know the relationship between age, irregular working schedules and diseases. The third step of mediation analysis is a multiple hierarchical regression analysis of irregular working schedules, smoking, drinking to know whether smoking and drinking are caused by irregular working. Multiple hierarchical regression analysis of irregular working schedules, smoking, drinking, and disease may explain whether smoking and drinking mediate between working irregularly and work-related diseases. Age is only used as a continuous reference variable in our analysis.

In this study, we used the same step of mediation analysis to analyse various work-related diseases. The way how we analyse these work-related diseases is still the same, but the data is different, so the diseases' results will also be different. Moreover, the study of every disease will have a common analysis step: multiple hierarchical regression analysis of irregular working schedules, smoking, and drinking. This step is explained in detail before we start to analyse each work-related disease. In the analysis of each disease, only the analysis results are listed concisely.

4. Results

Based on the physical examination results, we conducted descriptive analyses of all inspections to determine the most common diseases of railway workers in Southwest China. After obtaining the proportions results, we analysed each work-related disease one by one in the following sections. We can know the relation between the prevalence of work-related diseases and workers' characteristics by chi-square test and figure the relationship between work-related diseases and irregular smoking and drinking with regression models.

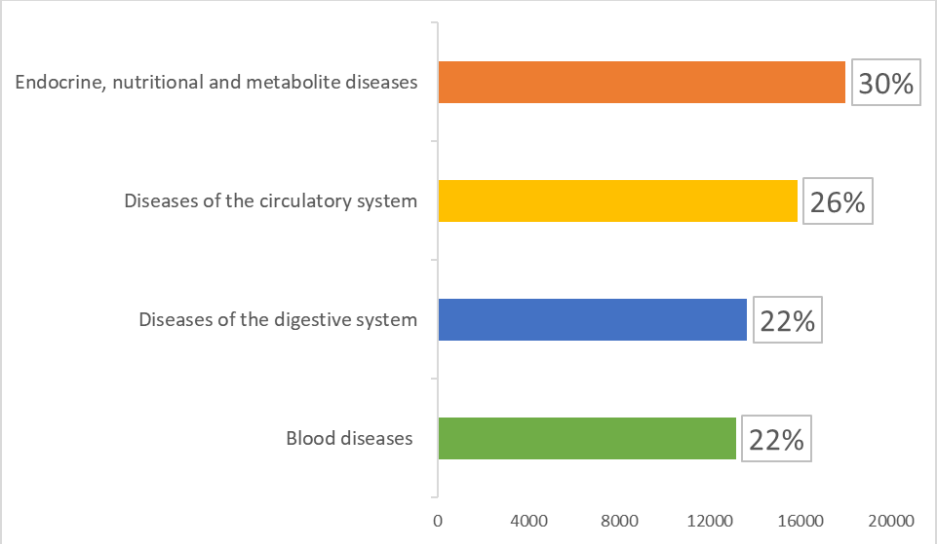
4.1 Common diseases of railway workers in Southwest China

According to the descriptive analyses, we found out that the most favourable results appear in the examination items related to metabolism, nutrition, and endocrine, digestive system, cardiovascular and blood. Based on the International Classification of Disease (ICD-10) version 2019 (World Health Organization, 2010), the positive results can be summarised into four types: endocrine, nutritional and metabolite disease, disease of the circulatory system, disease of the digestive system and diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (blood disease).

The results show that the number of endocrines, nutritional and metabolite disease is the highest. The four conditions are listed as follows descending order of the number of people (Figure 3).

Figure 3

The Arrangement of the Four Diseases



4.2 Identical steps used for analysing four work-related diseases

Because the mediation analysis of every work-related disease will use a same step to know the relationship between irregular working schedule, drinking and smoking, at the beginning of we analysis each disease, we will explain in detail this step. In the following analysis of each disease, only the analysis results were be showed.

To answer these two questions: (1) Does working irregular predict drinking? (2) Does working irregular predict smoking? This step uses working irregular as the independent variable and smoking and drinking as the dependent variable to perform a hierarchical regression analysis.

From the irregular working schedule and drinking model (see Table 1), the regression coefficient of working irregular is 0.025, and it is significant ($p<0.01$), which implies that working irregular will have a significant positive impact on drinking. The R^2 values ranged from .002 to .0.03. It was suggesting a small but significant for working irregular to also predict drinking.

Furthermore, as we can see from the irregular working schedule and smoking model from Table 2 below, the relationship of working irregular with smoking was also significant ($p<0.01$). The range of R^2 changed from .032 to .031, implying a small but significant for working to predict smoking.

Table 1

The Relationship between Working and Drinking

	Hierarchical 1					Hierarchical 2				
	B	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*
Constant	0.604**	0.011	53.175	0.000	-	0.586**	0.012	47.498	0.000	-
Age	0.002**	0.000	7.056	0.000	0.046	0.002**	0.000	7.741	0.000	0.052
Irregular working						0.025**	0.007	3.764	0.000	0.025
R^2	0.002					0.003				
F value	*F* (1,23204) =49.794, *p*=0.000					*F* (2,23203) =31.993, *p*=0.000				

Dependent Variable: Drinking

* $p<0.05$ ** $p<0.01$

Table 2

The Relationship between Working Irregular and Smoking

	Hierarchical 1					Hierarchical 2				
	B	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*
Constant	0.262**	0.012	22.066	0.000	-	0.229**	0.013	17.746	0.000	-
Age	0.008**	0.000	27.133	0.000	0.175	0.008**	0.000	27.953	0.000	0.186
Irregular working						0.046**	0.007	6.623	0.000	0.044
R^2	0.031					0.032				
F value	*F* (1,23206) =736.182, *p*=0.000					*F* (2,23205) =390.701, *p*=0.000				

Dependent Variable: Smoking

* $p<0.05$ ** $p<0.01$

4.3 Endocrine, nutritional and metabolite diseases

Through chi-square, the situation of all employees can be obtained (see Table 3). A total of 18,001 people suffer from endocrine, nutritional and metabolite diseases, with an average age of 40.69±10.9. Among them, the 50-59 age group has the highest prevalence (84%). People with irregular working schedules (79%), smoking (80%) and drinking (81%) have a higher probability of getting endocrine, nutritional and metabolite diseases.

Table 3

Relation Between the Prevalence of Endocrine, Nutritional and Metabolite Diseases and Workers Characterises

Variable	Subgroup	endocrine, nutritional and metabolite diseases (%)		Total	χ^2	p
		No	Yes			
Age	19-29	2185 (32%)	4572 (68%)	6757	562.523	0.000**
	30-39	743 (23%)	2559 (77%)	3302		
	40-49	1474 (19%)	6367 (82%)	7841		
	50-59	855 (16%)	4481 (84%)	5336		
	60-65	7 (24%)	22 (76%)	29		
	total	5264	18001	23265		
Working schedule	Regular	3648 (23%)	12008 (77%)	15656	12.447	0.000**
	Irregular	1616 (21%)	5993 (79%)	7609		
	total	5264	18001	23265		
Smoking history	No	2630 (26%)	7295 (74%)	9925	148.576	0.000**
	Yes	2621 (20%)	10662 (80%)	13283		
	total	5251	17957	23208		
Drinking history	No	2176 (29%)	5230 (71%)	7406	283.399	0.000**
	Yes	3075 (19%)	12725 (81%)	15800		
	total	5251	17955	23206		

* $p<0.05$ ** $p<0.01$

4.3.1 Mediation analysis of endocrine, nutritional and metabolite diseases

There are four steps to do the mediation analysis of endocrine, nutritional and metabolite diseases. The first step is spearman correlation. The second step is a multiple hierarchical regression analysis of irregular working schedules and endocrine, nutritional and metabolite diseases. The third step is a multiple hierarchical regression analysis of irregular working schedules and drinking and smoking. Moreover, the fourth step is a multiple hierarchical regression analysis of irregular working schedules, smoking, drinking and endocrine, nutritional and metabolite diseases.

(1) Correlation

Spearman correlation analysis (see Table 4) shows correlations between endocrine, nutritional, metabolite diseases, age, drinking history, smoking history, and irregular working. The coefficient values are greater than 0, consequently a positive correlation between endocrine, nutritional, metabolite diseases, age, drinking, smoking, and working irregularly.

Table 4

Correlation of Age, Working Irregular, Drinking, Smoking and Endocrine, Nutritional and Metabolite Diseases

		Endocrine, nutritional and metabolite diseases	Age	Drinking	Smoking	Irregular working
Endocrine, nutritional and metabolite diseases	Coefficient	1				
	p-value					
Age	Coefficient	0.148**	1			
	p-value	0.000				
Drinking	Coefficient	0.111**	0.047**	1		
	p-value	0.000	0.000			
Smoking	Coefficient	0.080**	0.170**	0.223**	1	
	p-value	0.000	0.000	0.000		
Irregular working	Coefficient	0.023**	-0.237**	0.013*	0.001	1
	p-value	0.000	0.000	0.044	0.916	

* $p<0.05$ ** $p<0.01$

(2) Multiple hierarchical regression analysis of irregular working schedule and endocrine, nutritional and metabolite diseases

Multiple hierarchical regression analysis of irregular working schedule and endocrine, nutritional and metabolite diseases step approved the relationship between the irregular working schedule and endocrine, nutritional and metabolite diseases.

See hierarchical 1 and 2 of Table 5. After controlling for age, an irregular working schedule is an essential factor in suffering from endocrine, nutritional and metabolic disease (β =0.062, $p<0.01$). The regression coefficient value of working irregular is .055, and it is significant ($t=9.333$, $p<0.01$). The R^2 values ranged from .023 to .027, which means a small but significant capacity for working irregular to predict endocrine, nutritional and metabolite diseases.

(3) Multiple hierarchical regression analysis of irregular working schedule and smoking, drinking

This section refers to the previous section of the multiple hierarchical regression analysis of irregular working schedules and smoking and drinking (see 4.2). An irregular working schedule will have a significant positive impact on smoking and drinking. In other worders, smoking and drinking may cause by working irregular.

(4) Multiple hierarchical regression analysis of irregular working schedule, smoking, drinking and endocrine, nutritional and metabolite diseases

The previous steps show that working irregular is an important factor influencing endocrine, nutritional and metabolite diseases. In this step, working irregular is used as the independent

variable, drinking and smoking is the mediating variable, and endocrine, nutritional and metabolite diseases is the dependent variable to do hierarchical regression to prove the mediating effect of drinking and smoking.

From Table 5, the results show that both smoking (β = 0.031, p<0.01) and drinking (β =0.096, p<0.01) have made new contributions to the model, which implies both of them can produce endocrine, nutritional and metabolite diseases. The regression coefficient of irregular working schedules is reduced from .062 (p<0.01) to .058 (p<0.01). The magnitude of the indirect effect of working irregular on endocrine, nutritional and metabolite diseases, through drinking and smoking, the range of R^2 changed from .027 to .038. It shows that smoking and drinking have a mediating role in the relationship between irregular working schedules and the endocrine, nutritional and metabolite diseases.

Table 5

The Relationship between Working Irregular, Smoking, Drinking, and Endocrine, Nutritional and Metabolite

	Hierarchical 1				Hierarchical 2				Hierarchical 3			
	B	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*
Constant	0.546**	0.010	54.143	0.000	-	0.506**	0.011	46.309	0.000	-	0.450**	0.011	39.482	0.000	-
Age	0.006**	0.000	23.455	0.000	0.152	0.006**	0.000	25.016	0.000	0.167	0.006**	0.000	23.142	0.000	0.156
Irregular working						0.055**	0.006	9.287	0.000	0.062	0.052**	0.006	8.758	0.000	0.058
Drinking											0.086**	0.006	14.459	0.000	0.096
Smoking											0.027**	0.006	4.672	0.000	0.031
R^2	0.023					0.027					0.038				
F value	*F* (1,23203) =550.143, *p*=0.000					*F* (2,23202) =319.210, *p*=0.000					*F* (4,23200) =229.788, *p*=0.000				

Dependent variable: Endocrine, nutritional and metabolite diseases

* $p<0.05$ ** $p<0.01$

4.4 Circulatory system diseases

According to statistics (see Table 6), a total of 15,864 people suffer from circulatory diseases. It can be concluded that the average age of illness is 40.68±11.20. The prevalence rate is the highest in the 60-65 age group (79%). Among the people with an irregular schedule, there are 72% of workers experienced circulatory system diseases. At the same time, more people who smoke (71%) and drink (70%) suffer from circulatory system diseases.

Table 6

Relation between the Prevalence of Circulatory System Diseases and Workers characterises

	Subgroup	Circulatory system diseases (%)		Total	χ^2	p
		No	Yes			
Age	19-29	2506 (37%)	4251 (63%)	6757	402.273	0.000**
	30-39	1296 (39%)	2006 (61%)	3302		
	40-49	2406 (31%)	5435 (69%)	7841		
	50-59	1187 (22%)	4149 (78%)	5336		
	60-65	6 (21%)	23 (79%)	29		
	total	7401	15864	23265		
Working schedule	Regular schedule	5250 (34%)	10406 (66%)	15656	65.417	0.000**
	Irregular schedule	2151 (28%)	5458 (72%)	7609		
	total	7401	15864	23265		
Smoking history	No	3586 (36%)	6339 (64%)	9925	148.175	0.000**
	Yes	3800 (19%)	9483 (71%)	13283		
	total	7386	15822	23208		
Drinking history	No	2577 (35%)	4829 (65%)	7406	44.297	0.000**
	Yes	4808 (30%)	10992 (70%)	15800		
	total	7385	15821	23206		

* p<0.05 ** p<0.01

4.4.1 Mediation analysis of circulatory diseases

The mediation analysis of circulatory diseases also includes four steps, one correlation, and three multiple hierarchical regression analyses.

(1) Correlation

From Table 7, there is a positive correlation between circulatory disease and age, drinking, smoking, and working irregular.

Table 7

Correlation of Age, Working Irregular, Drinking, Smoking and Circulatory System Diseases

		Circulatory system disease	Age	Drinking	Smoking	Irregular working
Circulatory system disease	Coefficient	1				
	p-value					
Age	Coefficient	0.121**	1			
	p-value	0.000				
Drinking	Coefficient	0.044**	0.047**	1		
	p-value	0.000	0.000			
Smoking	Coefficient	0.080**	0.170**	0.223**	1	
	p-value	0.000	0.000	0.000		
Irregular working	Coefficient	0.053**	-0.237**	0.013*	0.001	1
	p-value	0.000	0.000	0.044	0.916	

* p<0.05 ** p<0.01

(2) Multiple hierarchical regression analysis of irregular working schedule and circulatory system diseases

In this step, we wanted to prove the relationship between working irregular and circulatory system diseases. Take working irregular as the independent variable and circulatory system diseases as the dependent variable.

It can be seen from Table 8 (Hierarchical 1 and 2) below that after controlling for the influence of age, and an irregular working schedule is an essential factor in circulatory diseases (β =0.086, $p<0.01$). The R^2 values ranged from .014 to .021, which means a small but significant capacity for working irregular to predict circulatory diseases.

(3) Multiple hierarchical regression analysis of irregular working schedule and smoking, drinking

Refer to the 4.2 section, and we can know that the irregular working schedule has explanatory power for smoking and drinking and has a significant positive impact on both.

(4) Multiple hierarchical regression analysis of irregular working schedule, smoking, drinking and circulatory system disease

In this multiple hierarchical regression analysis, we verified the intermediary role of drinking and smoking.

Table 8 shows that an irregular working schedule is an essential factor influencing the disease (β =0.086, $p<0.01$). With the addition of drinking and smoking in the model, the regression coefficient of irregular working schedules is reduced from .086 ($p<0.01$) to .083 ($p<0.01$). The magnitude of the indirect effect of working irregular on circulatory system diseases, through drinking and smoking, the range of R^2 changed from .021 to .025. It shows that smoking and drinking have a mediating role in the relationship between irregular working schedules and circulatory system diseases.

Table 8

The Relationship between Working Irregular, Smoking, Drinking, and Circulatory System Diseases

	Hierarchical 1					Hierarchical 2					Hierarchical 3				
	B	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*
Constant	0.483**	0.011	42.814	0.000	-	0.421**	0.012	34.531	0.000	-	0.396**	0.013	30.967	0.000	-
Age	0.005**	0.000	18.330	0.000	0.119	0.006**	0.000	20.887	0.000	0.139	0.005**	0.000	18.968	0.000	0.129
Irregular working						0.085**	0.007	12.865	0.000	0.086	0.082**	0.007	12.439	0.000	0.083
Drinking											0.025**	0.007	3.777	0.000	0.025
Smoking											0.049**	0.006	7.679	0.000	0.052
R^2	0.014					0.021					0.025				
F value	*F* (1,23203) =335.977, *p*=0.000					*F* (2,23202) =251.938, *p*=0.000					*F* (4,23200) =148.981, *p*=0.000				

Dependent variable: Circulatory system disease

* $p<0.05$ ** $p<0.01$

4.5 Diseases of the digestive system

From Table 9, a total of 13,655 people suffer from digestive diseases, with an average age of 41.02±10.73. Among them, the highest prevalence rate in the 50-59 age group is 65%. Most people with digestive system diseases have working irregular (60%), smoking history (61%), and drinking history (61%).

Table 9

Relation between the Prevalence of Digestive Diseases and Workers Characterises

	Subgroup	Digestive diseases (%)		Total	χ^2	*p*
		No	Yes			
Age	19-29	3513 (52%)	3244 (48%)	6757	464.513	0.000**
	30-39	1306 (40%)	1996 (60%)	3302		
	40-49	2903 (37%)	4938 (63%)	7841		
	50-59	1877 (35%)	3459 (65%)	5336		
	60-65	11 (38%)	18 (62%)	29		
	total	9610	13655	23265		
Working schedule	Regular	6557 (42%)	9099 (58%)	15656	6.529	0.011*
	Irregular	3053 (40%)	4556 (60%)	7609		
	total	9610	13655	23265		

Subgroup		Digestive diseases (%)		Total	χ^2	*p*
		No	Yes			
Smoking history	No	4424 (45%)	5501 (55%)	9925		
	Yes	5164 (39%)	8119 (61%)	13283	76.056	0.000**
total		9588	13620	23208		
Drinking history	No	3406 (46%)	4000 (54%)	7406		
	Yes	6183 (39%)	9617 (61%)	15800	97.776	0.000**
total		9589	13617	23206		

* $p<0.05$ ** $p<0.01$

4.5.1 Mediation analysis of digestive diseases

As the same as mediation analysis of other diseases, the analysis of digestive diseases also included four steps.

(1) Correlation

As shown in Table 10, ages, drinking, smoking, and irregular working hours, are included in the correlation analysis. All four items have a positive correlation between digestive diseases.

Table 10

Correlation of Age, Working irregular, drinking, smoking and digestive diseases

		Digestive Disease	Age	Drinking	Smoking	Irregular working
Digestive Disease	Coefficient	1				
	p-value					
Age	Coefficient	0.130**	1			
	p-value	0.000				
Drinking	Coefficient	0.065**	0.047**	1		
	p-value	0.000	0.000			
Smoking	Coefficient	0.057**	0.170**	0.223**	1	
	p-value	0.000	0.000	0.000		
Irregular working	Coefficient	0.017*	-0.237**	0.013*	0.001	1
	p-value	0.011	0.000	0.044	0.916	

	Digestive Disease	Age	Drinking	Smoking	Irregular working

* $p<0.05$ ** $p<0.01$

(2) Multiple hierarchical regression analysis of irregular working schedule and digestive diseases

In this step, we proved that an irregular working schedule is an essential factor affecting digestive diseases.

After controlling for the influence of age, the irregular working schedule is an essential factor in digestive disease (β =0.051, p<0.01). As shown from Table 11 hierarchical 1 and 2 below, The R^2 values varied from.018 to.020, indicating a minor but considerable potential for predicting digestive illnesses when working irregularly.

(3) Multiple hierarchical regression analysis of irregular working schedule and smoking, drinking

This analysis step is the same as the multiple hierarchical regression analysis of irregular working schedule and smoking, drinking in the previous disease model's action (see 4.2). From the previous section, we know that an irregular working schedule will cause workers to appear smoking and drinking.

(4) Multiple hierarchical regression analysis of irregular working schedule, smoking, drinking and digestive disease

In this step, we use working irregular as the independent variable, drinking and smoking as the mediating variable, and digestive diseases as the dependent variable to perform a multivariate hierarchical regression analysis to prove the mediating role of drinking and smoking.

After controlling the influence of age, an irregular working schedule is essential for digestive disease (β=0.051, p<0.01). The regression coefficient of irregular working schedules decreased from 0.051 (p<0.01) to 0.048 (p<0.01). The amplitude of the indirect effect of irregular working hours on digestive disorders, as a result of drinking and smoking, R^2 increased from.020 to.024. It suggests that smoking and drinking may play a role in moderating the link between irregular work hours and digestive disorders. (see Table 11).

Table 11

The Relationship between Working Irregular, Smoking, Drinking, and Digestive Diseases

	Hierarchical 1					Hierarchical 2					Hierarchical 3				
	B	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*
Constant	0.351**	0.012	29.498	0.000	-	0.313**	0.013	24.232	0.000	-	0.275**	0.014	20.362	0.000	-
Age	0.006**	0.000	20.583	0.000	0.134	0.006**	0.000	21.806	0.000	0.146	0.006**	0.000	20.503	0.000	0.139
Irregular working						0.053**	0.007	7.574	0.000	0.051	0.051**	0.007	7.240	0.000	0.048
Drinking											0.056**	0.007	7.994	0.000	0.053
Smoking											0.021**	0.007	3.101	0.002	0.021
R^2	0.018					0.020					0.024				
F value	*F* (1,23203) =423.665, *p*=0.000					*F* (2,23202) =241.031, *p*=0.000					*F* (4,23200) =143.094, *p*=0.000				

Dependent variable: Diseases of the digestive system

* $p<0.05$ ** $p<0.01$

4.6 Blood Diseases

Table 12 shows the relation between the prevalence of blood diseases and workers characterises. 13,165 people are suffering from blood diseases, with an average age of 39.03±11.08. The population with disease is mainly concentrated in the 19-39 age group. People with irregular working schedules (63%) have a higher prevalence rate than those who regularly start to work to have blood diseases. Among people with smoke and drink, more people have blood diseases than those who are not.

Table 12

Relation between the Prevalence of Blood Diseases and Workers Characterises

	subgroup	Blood diseases (%)		Total	χ^2	p
		No	Yes			
Age	19-29	2637 (39%)	4120 (61%)	6757	130.578	0.000**
	30-39	1341 (40%)	1961 (60%)	3302		
	40-49	3512 (45%)	4329 (55%)	7841		
	50-59	2593 (49%)	2743 (51%)	5336		
	60-65	17 (59%)	12 (41%)	29		
total		10100	13165	23265		
Working schedule	Regular	7250 (46%)	8406 (54%)	15656	163.342	0.000**
	Irregular	2850 (37%)	4759 (63%)	7609		

subgroup		Blood diseases (%)		Total	χ^2	p
		No	Yes			
total		10100	13165	23265		
Smoking history	No	4971 (50%)	4954 (50%)	9925		
	Yes	5104 (38%)	8179(62%)	13283	314.410	0.000**
Total		10075	13133	23208		
Drinking history	No	3638 (49%)	3768(51%)	7406		
	Yes	6437(41%)	9363(59%)	15800	144.203	0.000**
Total		10075	13131	23206		

* p<0.05 ** p<0.01

4.6.1 Mediation analysis of blood diseases.

Like the analysis of other diseases, the mediation analysis of blood diseases also includes four steps. In this section, we will talk about it in detail.

(1) Correlation

According to Table 13, Spearman correlation analysis shows that smoking, drinking, and irregular working schedule are directly correlated with blood diseases, but age is negatively associated with blood diseases, but all of them are significant to the blood diseases.

Table 13

Correlation of Age, Working Irregular, Drinking, Smoking and Blood Diseases

		Age	Irregular working	Drinking	Smoking	Blood disease
Age	Coefficient	1				
	p-value					
Irregular working	Coefficient	-0.237**	1			
	p-value	0.000				
Drinking	Coefficient	0.047**	0.013*	1		
	p-value	0.000	0.044			
Smoking	Coefficient	0.170**	0.001	0.223**	1	
	p-value	0.000	0.916	0.000		
Blood disease	Coefficient	-0.078**	0.084**	0.079**	0.116**	1
	p-value	0.000	0.000	0.000	0.000	

* p<0.05 ** p<0.01

(2) Multiple hierarchical regression analysis of irregular working schedule and blood diseases

In this part, we need to prove that working irregular is an essential factor affecting workers' blood diseases.

After controlling the influence of age, the irregular working schedule is an essential factor influencing blood diseases. When the irregular working schedule is added to the model based on the age-independent variable, working irregular will significantly ($p<0.01$) positively influence blood diseases. The R^2 values ranged from .006 to .010, which means a small but significant capacity for working irregular to predict circulatory diseases (see Table 14 hierarchical 1 and 2).

(3) Multiple hierarchical regression analysis of irregular working schedule and smoking, drinking

As mentioned in 4.2, irregular working schedules can lead workers to drink and smoke.

(4) Multiple hierarchical regression analysis of irregular working schedule, smoking, drinking and blood disease

Based on the previous analysis, in this part, we used working irregular as the independent variable, drinking and smoking as the mediating variable. Blood diseases as the dependent variable for regression analysis to verify the mediating role of drinking and smoking.

From Table 14, we can know that an irregular working schedule is an essential factor influencing the disease ($\beta=0.07$, $p<0.01$). The results show that both smoking ($\beta = 0.119$, $p<0.01$) and drinking ($\beta =0.05$, $p<001$) have made new contributions to the model, thereby both of them can produce blood diseases. The regression coefficient of irregular working schedules decreased from 0.074 ($p<0.01$) to 0.067 ($p<0.01$). The amplitude of the indirect effect of irregular working hours on blood diseases, as an R^2 result of drinking and smoking, increased from .010 to .030. It demonstrates that smoking and drinking have a role in moderating the link between irregular work patterns and blood diseases.

Table 14

The Relationship between Working Irregular, Smoking, Drinking, and Blood Diseases

	Hierarchical 1					Hierarchical 2					Hierarchical 3				
	B	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*
Constant	0.701**	0.012	58.154	0.000	-	0.647**	0.013	49.583	0.000	-	0.586**	0.014	43.204	0.000	-
Age	-0.003**	0.000	-11.627	0.000	-0.076	-0.003**	0.000	-8.898	0.000	-0.060	-0.004**	0.000	-12.530	0.000	-0.085
Irregular working						0.074**	0.007	10.445	0.000	0.070	0.067**	0.007	9.543	0.000	0.064
Smoking											0.119**	0.007	17.645	0.000	0.119
Drinking											0.059**	0.007	8.347	0.000	0.055

	Hierarchical 1					Hierarchical 2					Hierarchical 3				
	B	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*	*B*	Std. Error	*t*	*p*	*β*
R^2	0.006					0.010					0.030				
F value	*F* (1,23203) =135.189, *p*=0.000					*F* (2,23202) =122.460, *p*=0.000					*F* (4,23200) =179.286, *p*=0.000				

Dependent Variable: Blood disease

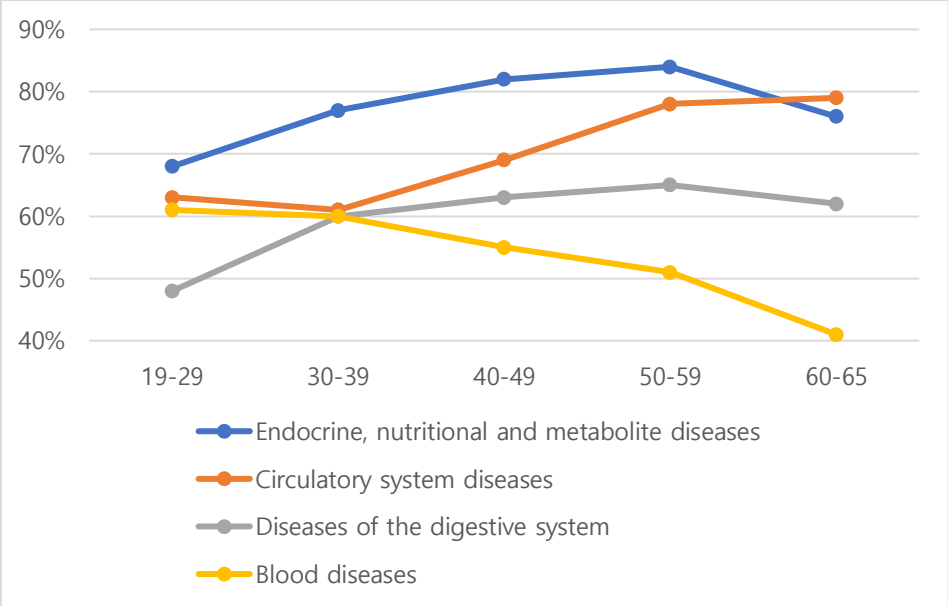
* $p<0.05$ ** $p<0.01$

4.7 Summaries for four work-related diseases

Among the four types of diseases, most blood diseases occur in young people (19-29 years old). The other three diseases have a high probability occur in people aged 50-59. The prevalence of all age groups is shown in Figure 4.

Figure 4

The prevalence of all age groups



The analysis results of irregular working schedules and smoking and drinking indicate that working irregulars will positively impact drinking and smoking. That is, working irregulars will lead to people smoking and drinking. This is consistent with what we found in the study of Kecklund and Axelsson (Figure 1) that people will eventually have risk behaviours (smoking, drinking) due to shifting work.

Moreover, we can confirm with the above analysis results that the practical model (see Figure 2) we proposed is suitable for this study. The direct connections between working irregularly and work-related disorders in all four disease mediation models are statistically significant. These statistical analysis results imply that the link between working irregular and endocrine,

nutritional metabolite disease, circulatory system diseases, digestive system diseases, blood diseases are mediated by drinking and smoking.

5. Discussion

5.1 Main findings

This study aims to find out the most common work-related health problem in railway workers in Southwest China. Through descriptive analysis, we found that high incidences among railway workers are endocrine, nutritional and metabolite disease, circulatory system diseases, digestive system diseases, blood diseases. Furthermore, the most disease that people get is endocrines, nutritional and metabolite disease. Combining our study with literature review (Zhang et al., 2016, Kolmodin-Hedman & Swensson, 1975), we had the same conclusion: railway workers have a higher probability of getting endocrine, metabolic cardiovascular and digestive system diseases than the general population.

Another objective of this study is through mediation analysis to know the relationships between the health risk factors (working irregular, drinking, smoking) and endocrine, nutritional and metabolite disease, circulatory system diseases, digestive system diseases, blood diseases. The final data analysis results prove the correctness of the theoretical model we put forward in the previous part of this article. Working irregular was statistically related to four work-related diseases.

The analysis confirmed that the irregular working schedule has a significant positive impact on four work-related diseases. Combined with the literature review above about the health problem of smoking and drinking, drinking and smoking can lead to endocrine, nutritional and metabolite disease, circulatory system diseases, digestive system diseases, blood diseases (Tsujii et al., 2013, Bullen, 2008, Wang et al., 2019, Scharf & Aul, 1988). Our findings are consistent with those of Kecklund and Axelsson, which build a model of changes in diet and behaviour patterns caused by shift work to confirm that the shift work will cause smoking and drinking (Figure 1). In this study, we also confirmed that both smoking and drinking have a mediating role in the relationship between irregular working schedules and the four types of work-related diseases, implying that smoking and drinking can be explained as part of the causes of the four diseases. Although the variance values for these models are small, drinking and smoking are the two significant factors of four diseases. The small association value between working irregular, smoking, and work-related diseases may be caused by some other factors. These factors could be sleeping patterns, eating habits, exercise etc, which we could not include in our study.

5.2 Theoretical contribution

This article fills in the gaps in the research on the health of railway workers in Southwest China. It provides a research foundation for future scholars and health decision-makers in this area, who can conduct detailed research on each disease based on the current results.

Current research about shift work mainly uses inductive reviews and field studies to summarise the health effects of shift work on everyone. These studies usually consider only one influencing factor and use single-factor analysis for summarising the overall relationship between work-related diseases and a specific work environment. For example, in Johanning et

al.'s study, the target railway workers are exposed to the specific hand-arm vibration (HAV). Johanning only discussed the single relationship between shock exposure and musculoskeletal diseases (Johanning et al., 2020). Instead of knowing the common problems about the railway workers, cross-sectional studies and field studies usually concentrated on a specific disease or environment. Consequently, the samples of studies were not big enough. A field study talked about the sleep problem of railway workers from the United Kingdom ((Fan & Smith, 2020), invited 19 people to participate in the research. A cross-sectional study about the musculoskeletal diseases of railway workers was included among 309 workers in Jhansi (U.P.) (Gupta et al., 2017). However, we have an extensive dataset with more than twenty thousand cases. We did not limit the research to a specific environment to have a comprehensive understanding of the health of the railway workers.

Compared to the inductive reviews (Costa, 2010), which only listed the related diseases of railway workers, including sleep problems, psychological problems, physiological diseases (digestive system disorders, metabolic disorders, heart disorders, cancer), but did not discuss the cause of illness. In this study, we also figure out the relationship between work-related diseases and risk factors. We believe that only by knowing the reasons, academics and government personnel can make better health management recommendations for railway workers.

Moreover, this study clarifies the concept of work-related diseases and occupational diseases. Our research also wants to remind scholars and health decision-makers instead of focusing on mental health problems and occupational diseases recorded on the Chinese occupational diseases list. The stakeholders should pay attention to the work-related diseases caused by irregular working schedules and unhealthy lifestyles to comprehensive policy to prevent and improve these work-related diseases in the future. The European Occupational Disease List, for example, includes many internationally recognised occupational diseases, ranging from diseases caused by chemical, biological, and physical agents to respiratory and skin diseases, musculoskeletal diseases, and occupational cancers, according to the European Agency for Safety and Health at Work. Mental and behavioural disorders are also included in the list of the ILO. However, some studies have shown that workers suffer from many diseases due to work, such as musculoskeletal diseases, cardiovascular and cerebrovascular diseases, mental and psychological diseases, and even die from overwork. These diseases have not yet been included in China's occupational diseases' catalogue (The Lancet, 2019). However, in China, only the diseases on the directory of occupational diseases can be concerned. As a result of the low frequency of occupational health examinations in China and the narrow scope of diseases defined in the occupational disease list, the prevalence of occupational and work-related disorders in China may be underestimated. Our research will lay the foundation for scholars to study work-related diseases that have not been included in the list of occupational diseases. And our research is helpful to expand China's occupational disease catalogue so that more work-related diseases are valued and included in the occupational disease catalogue.

5.3 Practical implications

Since most railways workers face shift work schedules during their whole career life, a clear policy is needed to protect workers' rest time and health by saving the irregular working schedule and guiding the workers' lifestyle. Based on the results of this study, we will give relative suggestions to the health care manager (organisation) and individual workers.

We highlight that the irregular working schedule is the crucial influencing factor of work-related diseases and figure out that irregular working schedules can cause unhealthy behaviour and lead to diseases. With the things we mentioned above, we want to leave some health messages to the scholars and health care policymakers to help them be more targeted when making health policies for railway workers, such as restricting the number and time of irregular working in the law. From the previous literature review, we know that the European Union's management of workers' shift work and health management is better than China's. Therefore, we hope to find out the current deficiencies in China by comparing relevant laws and policies in the European Union and putting forward suggestions for improvement. European Union Commission is aware of the dangers of shift work and has issued some directives to restrict working hours and shift schedules. Workers' rest time must meet minimal safety and health requirements, which include daily rest, weekly rest, maximum weekly working hours, annual leave, and night working hours, according to Directive 1993/104/EC. The directive 2003/88/EC of the European Parliament and the Council on 4 November 2003 made significant changes to shift work, work patterns, and other rules (Council of European Communities, 1989). According to Chapter 2 of the Council Directive 2003/88/EC, all workers receive enough rest time. The concept of "rest" must be defined in terms of time units, such as days, hours, and minutes. Employers are required by law to provide workers with a minimum of daily, monthly, and yearly rest time and adequate rest space.

Furthermore, where necessary, the directive also stipulates the maximum working hours per week. Article 3 of 2003/88/EC stipulates that member states shall take necessary measures to ensure that every worker has the right to have at least 11 consecutive hours of rest for every 24 hours of work. In Article 5, precision is made for a weekly rest period. Every member state should ensure that every 7-day period, workers are entitled to at least 24 hours of uninterrupted rest, plus 11 hours of rest per day as described in Artide 3. Article 6 stipulates that the duration of continuous work every 7 days shall not exceed 48 hours (European Parliament, Council of the European Union, 2003).

However, in China, only Articles 36-38 of the Labor Law stipulate that the country implements regulations for workers' daily working hours, weekly working hours, and overtime hours (Chinese government, 1994). Nevertheless, there is no restriction on shift work. So relevant laws and regulations need to be improved.

Hence, we noticed that Chinese law, policy, and health management guidance for individual workers is inadequate. In this study, we try to compare with the law in the EU and give relative suggestions to the organisation to complete the law or policy and give health management suggestions to the individual workers in China.

5.3.1 Health care manager (organisational) strategies

Shift work must be restricted by law to ensure the health of workers. Related policies need to be further improved to clarify the daily working hours and rest time and the interval between each shift. The shift plan should try to avoid sleep deprivation, day and night interference, at least 11 hours of recovery time between the two shifts, and no more than 60 hours of work per week, of which the shift time should not exceed 10 hours. Control individual working hours and adjust excessive working hours. The governments should require the companies to provide

health training for shift workers to deal with shift work, gradually solve acute sleep and fatigue problems, to provide long-term health. Furthermore, the related health department should regularly screen and treat shift workers for work-related disorders (Kecklund & Axelsson, 2016).

5.3.2 Individual strategies

The government and organisations cannot supervise everyone's diet and behaviour, so self-health management depends on everyone's conscious implementation. Relevant organisations can provide suitable methods and suggestions that are beneficial to health, and then workers need to follow the guideline to complete health management.

In situations when shifts, especially night shifts that cannot be avoided, some strategies can be adopted to ensure that workers can have enough sleep during the day to reduce the symptoms associated with shifts. One method is to promote circadian adaptation to atypical work arrangements, such as using bright white or dark blue monochromatic light at night and neutral grey or orange spectacles in the morning when exposed to sunlight. To avoid interfering with daytime sleep, workers should avoid psychostimulants, such as caffeine, at the end of the night shift. Other measures, such as strategic naps lasting 20-120 minutes and work roster design to maximise rest periods, have been proposed to maximise rest within 24 hours. There are two sorts of strategic napping: "preventive naps" arranged the night before shifts to limit predicted sleep deprivation and "restorative naps" used at night to temporarily ease drowsiness (Boivin & Boudreau, 2014). Where possible, the sleep environment is designed to promote sleep patterns during the day, exceptionally light, temperature, and noise levels. A lower ambient temperature, usually between 60 and 75 degrees Fahrenheit, can help sleep. Furthermore, use blackout curtains to minimise the sun as much as possible (Cheng & Drake, 2019).

Shift workers should work towards a healthy life. Workers need to learn health-related knowledge and manage their health. A healthy lifestyle includes a healthy diet, controlling the amount of food consumed at night, physical exercise, avoiding smoking and excessive drinking (Kecklund & Axelsson, 2016).

5.4 Limitations and suggestions for future research

Physical examination centres can only investigate the physical condition of workers through health examinations and oral questionnaires, so the exposure factors that can be examined are limited. From the literature review, we can know that work-related diseases are also influenced by other behaviours, such as eating habits, exercise, et al. In order to have a comprehensive analysis of the causes of work-related diseases, we recommend the future studies also include the factors that are mentioned above.

From the literature review, we did not find any studies to prove that railway workers have a higher probability of getting blood diseases. However, according to the statistical analyses, in our case, blood diseases are one of the most common diseases in railway workers. We think this is due to the geographical environment of our research site. Part of our sample population is from Guizhou province of China, which is located on a plateau. Medical research has shown

that the standard haemoglobin value of residents living in plateau areas is higher [1] than residents at sea level (Windsor & Rodway, 2007). Moreover, long-term alcohol intake can lead to various types of hemolytic anaemia (Scharf & Aul, 1988). This study also includes the effect of alcohol on work-related blood diseases; it is another reason that railway workers in Southwest China have a higher chance of suffering from a blood disease. Therefore, the results of blood diseases in this study are not representative.

Furthermore, through internal investigations, we have determined the people who will have irregular working schedules based on the work characteristics of the workers' positions. However, due to the chaotic management within the railway company, we cannot know the average hours of day shifts, average hours of evening shifts, work schedules and shift schedules for people who have irregular working schedules. In addition, because more than 20,000 employees participated in this research as the research object, the survey on sleep time and sleep quality has not yet been added in the first phase of the research survey. So we can only know that irregular working schedules will affect sleep. To understand how it affects workers' health, we will conduct a questionnaire on sleep time and sleep quality for the study's second phase.

The results of mediation analysis are extremely low, only significant due to the considerable sample size. Therefore, other research methods can determine the relationship between the irregular working schedule and unhealthy behaviours and work-related diseases for future study.

5.5 Conclusion

This study analysed the positive results of 23265 workers. It concluded that the work-related diseases with the highest incidence of diseases among workers are endocrine, nutritional, and metabolite disease, circulatory system diseases, digestive system diseases, and blood diseases. Endocrine, nutritional and metabolite disease, circulatory system diseases, digestive system diseases have a high probability of occurring in people aged 50-59. Moreover, through mediation analysis, we have confirmed that shift work is an essential factor that causes workers to get sick among these four work-related diseases. Smoking and drinking played an intermediary role in the model. In other words, Work-related diseases may be directly caused by irregular working or indirectly caused by drinking and smoking (which is caused by irregular working). Understanding the impact of these risk factors on health can better understand the mechanism of adverse health effects of shifts, facilitate better scheduling, and legislate on working hours; it is also easier to screen biological indicators and formulate corresponding countermeasures.

To solve shift work, the government should formulate detailed laws that stipulate the rights and obligations of workers and employers to protect workers' health. For example, limit the shift time, establish a scientific shift pattern, provide screens for work-related diseases and long-term health. At the same time, for individual workers, shift workers should pay attention to their health. Some measures can be provided to railway workers to ensure that workers can get

[1] High haemoglobin value is one of blood diseases

enough rest after getting off shift work. Workers need to get training to manage their health and choose a healthy lifestyle as much as possible, even when shifting work.

With the support of laws, policies, the joint efforts of health care managers and individual people, work-related diseases can be taken seriously and prevented so that the health of workers can be improved.

References

Allada, R., & Bass, J. (2021). Circadian mechanisms in medicine. *New England Journal of Medicine, 384*(6), 550-561.

Anyanwu, E., & Watson, N. (1997). Alcohol dependence: a critical look at the effects of alcohol metabolism. *Reviews on Environmental Health, 12*(3), 201-213.

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173-1182.

Boivin, D. B., & Boudreau, P. (2014). Impacts of shift work on sleep and circadian rhythms. *Pathologie Biologie, 62*(5), 292-301.

Bullen, C. (2008). Impact of tobacco smoking and smoking cessation on cardiovascular risk and disease. *Expert Review of Cardiovascular Therapy, 6*(6), 883-895.

Carrino, D., Branca, J. J. V., Becatti, M., Paternostro, F., Morucci, G., Gulisano, M., Di Cesare Mannelli, L., & Pacini, A. (2021). Alcohol-induced blood-brain barrier impairment: an in vitro study. *International Journal of Environmental Research and Public Health, 18*(5), 2683.

Cheng, P., & Drake, C. (2019). Shift work disorder. *Neurologic Clinics, 37*(3), 563-577.

Cheng, Y. H. (2011). Epidemiologic Investigation on the Health Status and Lifestyle Factors among the Shift Workers in Chinese Population. *Huazhong University of Science and Technology. China Academic Journal Electronic Publishing House.*

Council of European Communities. (1989). Council directive of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers. *89 / 391 / EEC*.

Costa, G. (2010). Shift work and health: current problems and preventive actions. *Safety and Health at Work, 1*(2), 112-123.

Chinese Government. (1994). Labour law of the People's Republic of China. *Eighth Meeting of the Standing Committee of the Eighth National People's Congress*

European Commission. (2003). Commission recommendation of 19 September 2003 concerning the European schedule of occupational diseases. *2003/670/EC*, 28-34.

European Parliament, Council of the Europeam Union. (2003). Directive 2003/88/EC of the European Parliament and of the Council of 4 November 2003 concerning certain aspects of the organisation of working time. *2003/88/EC*

Fan, J., & Smith, A. P. (2020). Effects of occupational fatigue on cognitive performance of staff from a train operating company: a field study. *Frontiers Psychology, 11*, 2366.

Gupta, S., Malhotra, A. K., Verma, S. K., & Yadav, R. (2017). In-depth analysis of pattern of occupational injuries and utilisation of safety measures among workers of railway wagon repair workshop in Jhansi (UP). *Indian Journal of Occupational and Environmental Medicine, 21*(3), 138.

Harma, M. (2006). Workhours in relation to work stress, recovery and health. *Scand Jounal of Work, Environment & Health, 32*(6), 502-514.

Health and Safety Executive. (2018). Work-related Ill Health in Railway Operatives. *Health and Safety Executive.*

Hosoda, Y., Hiraga, Y., & Sasagawa, S. (2008). Railway and asbestos in Japan(1928-1987)--Epidemiology of pleural plaques, malignancies and pneumoconioses. *Journal of Occupational Health, 50*, 297-307.

Huxley, R., R., & Woodward, M. (2011). Cigarette smoking as a risk factor for coronary heart disease in women compared with men: a systematic review and meta-analysis of prospective cohort studies. *The Lancet, 378*(9799), 1297-1305.

Jairo-Ernesto, L. G. (2020). Workers' sacrifice: the construction of Colombia's railways. *HesaMag, 22.*

Jensen, J. H., Flachs, E. M., Skakon, J., Rod, N. H., & Bonde, J. P. (2019). Longitudinal associations between organisational change, work-unit social capital, and employee exit from the work unit among public healthcare workers: a mediation analysis. *Scandinavian Journal of Work Environment & Health, 45*(1), 53-62.

Jiang, Y., Wu, C., Hu, T., Chen, M., Liu, W., Zhou, Y., Chen, Z., & Xu, X. (2020). Association for combined exposure to job strain, shift work on mental health among Chinese railway workers: a cross-sectional study. *BMJ Open, 10*(10), e037544.

Johanning, E., Stillo, M., & Landsbergis, P. (2020). Powered-hand tools and vibration-related disorders in US-railway maintenance-of-way workers. *Industrial Health, 58*(6), 539-553.

Kecklund, G., & Axelsson, J. (2016). Health consequences of shift work and insufficient sleep. *BMJ, 355*, i5210.

Kolmodin-Hedman, B., & Swensson, A. (1975). Problems related to shift work. A field study of Swedish railroad workers with irregular work hours. *Scandinavian Journal of Work, Environment & Health, 1*(4), 254-262.

Lie, A., Skogstad, M., Johnsen, T. S., Engdahl, B., & Tambs, K. (2014). A cross-sectional study of hearing thresholds among 4627 Norwegian train and track maintenance workers. *BMJ Open, 4*(10), e005529.

Lowden, A., Moreno, C., Holmback, U., Lennernas, M., & Tucker, P. (2010). Eating and shift work - effects on habits, metabolism and performance. *Scand Journal of Work, Environment & Health, 36*(2), 150-162.

Mallampalli, A., & Guntupalli, K. K. (2004). Smoking and systemic disease. *Clinics in Occupational and Environmental Medicine, 5*(1), 173-192.

MacKinnon, D. P., Fairchild, A. J., & Fritz, M. S. (2007). Mediation analysis. *Annual Review Psychology*, *58*, 593-614.

Office of Rail and Road. (2019). ORR's review of health risk management in the rail industry for 2014-2019. *Closing the Gap on Health, 5*.

Otterbring, T., Pareigis, J., Wastlund, E., Makrygiannis, A., & Lindstrom, A. (2018). The relationship between office type and job satisfaction: Testing a multiple mediation model through ease of interaction and well-being. S*candinavian Journal of Work Environment, 44*(3), 330-334.

Park, H. R., Shin, S. R., Han, A. L., & Jeong, Y. J. (2015). The correlation between the triglyceride to high density lipoprotein cholesterol ratio and computed tomography-measured visceral fat and cardiovascular disease risk factors in local adult male subjects. *Korean Journal of Family Medicine, 36*(6), 335-340.

Paterson, J. L., Dorrian, J., Clarkson, L., Darwent, D., & Ferguson, S. A. (2012). Beyond working time: factors affecting sleep behaviour in rail safety workers. *Accident Analysis & Prevention, 45*, 32-35.

Plotnikoff, R. C., Pickering, M. A., Flaman, L. M., & Spence, J. C. (2010). The role of self-efficacy on the relationship between the workplace environment and physical activity: a longitudinal mediation analysis. *Health Education & Behavior*, *37*(2), 170-185.

Puddey, I. B., & Beilin, L. J. (2006). Alcohol is bad for blood pressure. *Clinical and Experimental Pharmacology and Physiology, 33*(9), 847-852.

Puttonen, S., Harma, M., & Hublin, C. (2010). Shift work and cardiovascular disease - pathways from circadian stress to morbidity. *Scand Journal of Work, Environment & Health, 36*(2), 96-108.

Scharf, R. E., & Aul, C. (1988). Alcohol-induced disorders of the hematopoietic system. *Zeitschrife fur Gastroenterologie, 26*, 75-83.

Takala, J., Hamalainen, P., Saarela, K. L., Yun, L. Y., Manickam, K., Jin, T. W., Heng, P., Tjong, C., Kheng, L. G., Lim, S., & Lin, G. S. (2014). Global estimates of the burden of injury and illness at work in 2012. *Journal of Occupational and Environmental Hygiene, 11*(5), 326-337.

The Lancet. (2019). Improving occupational health in China. *The Lancet, 394*.

Tsujii, M., Iijima, H., Nishida, T., & Takehara, T. (2013). Smoking and alimentary diseases. Nihon insho. *Japanese Journal of Clinical Medicine, 71*(3), 436-442.

Vandelanotte, C., Short, C., Rockloff, M., Di Millia, L., Ronan, K., Happell, B., & Duncan, M. J. (2015). How do different occupational factors influence total, occupational, and leisure-time physical activity? *Journal of Physical Activity & Health*, *12*(2), 200-207.

Virtanen, M., Jokela, M., Nyberg, S. T., Madsen, I. E., Lallukka, T., Ahola, K., ... & Kivimäki, M. (2015). Long working hours and alcohol use: systematic review and meta-analysis of published studies and unpublished individual participant data. *BMJ*, 350.

Wang, W. J., Xiao, P., Xu, H. Q., Niu, J. Q., & Gao, Y. H. (2019). Growing burden of alcoholic liver disease in China: A review. *World Journal of Gastroenterology, 25*(12), 1445-1456.

Wickwire, E. M., Geiger-Brown, J., Scharf, S. M., & Drake, C. L. (2017). Shift work and shift work sleep disorder: clinical and organisational perspectives. *Chest, 151*(5), 1156-1172.

Windsor, J. S., & Rodway, G. W. (2007). Heights and haematology: the story of haemoglobin at altitude. *Postgraduate Medical Journal, 83*(977), 148-151.

World Health Organization. (2010). International statistical classification of diseases and related health problems 10th revision, Version for 2010.

Zhang, X., Chen, G., Xu, F., Zhou, K., & Zhuang, G. (2016). Health-Related Quality of Life and Associated Factors of Frontline Railway Workers: A Cross-Sectional Survey in the Ankang Area, Shaanxi Province, China. *International Journal of Environmental Research and Public Health, 13*(12).