



UNIVERSITI PUTRA MALAYSIA

***EFFECTS OF METALWORKING FLUID EXPOSURE ON RESPIRATORY
AND SKIN HEALTH AND AN AWARENESS PROGRAM TO PROTECT
WORKERS IN A METAL MACHINING FACTORY***

MOHAMMED ABDULRAZZAQ JABBAR

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By

MOHAMMED ABDULRAZZAQ JABBAR

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
in Fulfillment of the Requirements for the Degree of Doctor of Philosophy**

January 2018

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DEDICATIONS

This thesis is dedicated to my wife, Ansam, who has been a constant source of love, support, and encouragement during the challenges throughout my post-graduate journey and life. I am truly thankful for having you in my life. This work also dedicated to my kids, Alameen and Janna, how provided me the joy, love, and happiness. Also to my parents, Abdulrazzaq and Bushra, who have always loved me unconditionally and whose good examples have taught me to work hard for the things that I aspire to achieve.



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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January 2018

Chair : Prof Zailina Binti Hashim, PhD
Faculty : Medicine and Health Sciences

Introduction: Metalworking fluid (MWF) was used during machining processes such as cutting, turning, and grinding of metals and it works to provide lubrication and cooling effects to the machines and products. The workers in the production section were exposed to the fluid through variant routes as inhalation and direct skin contacts. The exposure could have lead to respiratory and skin health complaints. **Objectives:** Phase I of the study aimed to determine the exposed workers' respiratory and skin health status as compared to unexposed and associate that with the level of exposure. Phase II aimed to evaluate the effectiveness of the individual awareness program on exposed workers by enhancing their compliances towards using the protective methods regularly and properly. **Methodology:** Phase I, 298 exposed with 97 unexposed workers were involved in a comparative cross-sectional study. Measurements of individual respiratory exposure to MWF and Heavy metals (Cr and Ni) were carried out using NIOSH 5524 and NIOSH 7300 methods respectively. Assessment of individual skin exposure was carried out using dermal exposure assessment method (DREAM). Respiratory and skin health were assessed using standardized questionnaires. Phase II, 240 of exposed workers, involved in phase I, were selected and allocated randomly for experimental and control groups in a randomized controlled trial. Assessment of workers' compliances to use the preventive measures on pre and post-intervention levels were carried out in addition to respiratory and skin health assessment. **Results:** Phase I showed the prevalence of respiratory symptoms among exposed workers were significantly higher nasal complaint ($p<0.001$) cough ($p<0.001$) cough with phlegm ($p=0.001$) as compared to unexposed workers. In the same time, the exposed workers had significantly higher reporting rate of skin symptoms on hand ($p<0.001$) forearm ($p<0.001$) and front torso ($p=0.001$) as compared to the unexposed group. Phase II of the study revealed that the intervention group on posttest had significantly higher likelihood towards using face mask (OR 1.75 CI 1.01-3.00), cleaning working area (OR 1.81 CI 1.01-3.04), changing working uniform (2.01 CI 1.37-3.61), and wearing gloves (OR 1.61 CI 1.03-2.90) as compared to the control group. On the other hand, on posttest level, the intervention group showed lower

prevalence of respiratory symptoms nasal complaints ($p=0.042$), cough ($p=0.014$), and cough with phlegm ($p=0.026$) as compared to the control group. The intervention group similarly showed significantly lower skin complaints on hands ($p=0.039$), forearms ($p=0.001$), and front torso ($p=0.008$) as compared to control group. **Conclusion:** respiratory and skin exposure to MWF leads to several respiratory and skin health complaints among workers in this metal machining factory and individual awareness program was effective method to improve the workers' compliances toward using preventive methods.



Abstrak tesis ini dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

**KESAN PERNAFASAN DAN KESIHATAN KULIT DISEBABKAN OLEH
PENDEDAHAN BENDALIR KERJA LOGAM DAN PROGRAM KESEDARAN
UNTUK MELINDUNGI PEKERJA DALAM BIDANG PEMESINAN LOGAM**

Oleh

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Pengenalan: Bendalir kerja logam (MWF) digunakan semasa proses pemesinan seperti memotong, mengubah, dan mengisar logam dan berfungsi untuk memberi kelinciran dan kesan penyejukan kepada mesin dan produk. Para pekerja pada bahagian pengeluaran terdedah kepada bendalir melalui pelbagai cara seperti menerusi sedutan dan sentuhan kulit secara langsung. Pendedahan ini boleh membawa kepada masalah pernafasan dan kesihatan kulit. **Objektif:** Fasa I kajian ini bertujuan untuk menentukan status pernafasan dan kesihatan pekerja yang terdedah berbanding dengan yang tidak terdedah dan mengaitkannya dengan tahap pendedahan. Fasa II bertujuan untuk menilai keberkesanan program kesedaran individu oleh pekerja yang terdedah dengan meningkatkan kepatuhan mereka terhadap penggunaan kaedah pelindung secara berterusan dan betul. **Metodologi:** Dalam Fasa I, seramai 298 pekerja terdedah bersama-sama 97 orang pekerja yang tidak terdedah terlibat dalam kajian rentas keratan perbandingan. Ukuran terhadap pendedahan pernafasan individu kepada bendalir kerja logam dan logam berat (Cr dan Ni) masing-masing telah dijalankan menggunakan kaedah NIOSH 5524 dan NIOSH 7300. Penilaian pendedahan kulit individu dijalankan dengan menggunakan kaedah penilaian dedahan dermis (DREAM). Pernafasan dan kesihatan kulit dinilai menggunakan soal selidik piawai. Dalam Fasa II, seramai 240 pekerja terdedah yang terlibat dalam fasa I, telah dipilih dan diperuntukkan secara rawak untuk tujuan eksperimen dan kumpulan kawalan dalam percubaan terkawal secara rawak. Penilaian kepatuhan para pekerja untuk menggunakan langkah pencegahan pada tahap pra dan pasca intervensi telah dilakukan sebagai tambahan kepada penilaian pernafasan dan kesihatan kulit. **Keputusan:** Fasa I menunjukkan kelaziman simptom pernafasan dalam kalangan pekerja terdedah ketara lebih tinggi iaitu aduan berkenaan hidung ($p < 0.001$) batuk ($p < 0.001$) batuk dengan kahak ($p = 0.001$) berbanding dengan pekerja yang tidak terdedah. Pada masa yang sama, laporan pekerja terdedah terhadap simptom kulit pada tangan adalah dengan kadar yang jauh lebih tinggi iaitu ($p < 0.001$) pada lengan ($p < 0.001$) dan bahagian depan badan ($p = 0.001$) berbanding dengan kumpulan yang tidak terdedah. Fasa II kajian menunjukkan bahawa kumpulan intervensi pada pasca ujian mempunyai kemungkinan yang lebih

tinggi ke arah menggunakan topeng muka (OR 1.75 CI 1.01-3.00), membersihkan kawasan kerja (OR 1.81 CI 1.01-3.04), menukar seragam kerja (2.01 CI 1.37-3.61), dan memakai sarung tangan (OR 1.61 CI 1.03-2.90) berbanding dengan kumpulan kawalan. Pada sisi yang lain, pada tahap pasca ujian, kumpulan intervensi menunjukkan kelaziman simptom pernafasan hidung ($p = 0.042$), batuk ($p = 0.014$), dan batuk dengan kahak ($p = 0.026$) berbanding kumpulan kawalan. Kumpulan intervensi juga menunjukkan penurunan aduan kulit pada tangan ($p = 0.039$), lengan ($p = 0.001$) dan bahagian depan badan ($p = 0.008$) berbanding kumpulan kawalan. Kesimpulan: Pendedahan pernafasan dan kulit terhadap bendalir kerja logam membawa kepada beberapa masalah pernafasan dan kesihatan kulit dalam kalangan pekerja di kilang pemesinan logam dan program kesedaran individu adalah kaedah yang berkesan untuk meningkatkan kepatuhan para pekerja terhadap penggunaan kaedah pencegahan.

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I certify that a Thesis Examination Committee has met on 10 January 2018 to conduct the final examination of Mohammed Abdulrazzaq Jabbar on his thesis entitled "Effects of Metalworking Fluid Exposure on Respiratory and Skin Health and an Awareness Program to Protect Workers in a Metal Machining Factory" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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LIST OF ABBREVIATIONS

API	Analytical Profile Index
BLV	Biologic limit values
BP	Blood pressure
CCOHS	Canadian Centre for Occupational Health and Safety
Cr	Chrome
DCR	Dumping, Cleaning and recharging
DGBB	Deep groove ball bearing
DREAM	Dermal Exposure Assessment Method
FEV ₁	Forced expiratory volume in second 1
FVC	Forced vital capacity
HP	Hypersensitivity pneumonitis
HSE	Health Safety Executive
IgG	Immunoglobulin G
MARDI	Malaysian Agricultural Research and Development Institute
MCCP	Medium-chain chlorinated paraffin
MWF	Metalworking fluid
NIOSH	National Institute of Occupational Safety and Health
Ni	Nickel
PEF	Peak expiratory flow
REL	Recommended Exposure level
RWC	Reasonable worst-case
SABB	Self-Alignment ball bearing
SDA	Sabouraud Dextrose Agar
SHARP	Safety and health assessment and research for prevention
SRB	Spherical Roller Bearing
TLV	Threshold limit values
TLV-C	Threshold limit values-ceiling
TLV-	Threshold limit values-short term limit
STEL	
TLV-	Threshold limit value-time weighted average
TWA	
TSA	Tryptone Soya Agar
TWA	Time-weighted average
VC	Vital Capacity
VITAE	Video imaging technique for assessing dermal exposure
VOC	Volatile organic compound
LEV	Local Exhaust Ventilation

CHAPTER 1

INTRODUCTION

1.1 Background

Metalworking fluids (MWFs) are a variety of substances that could be used during the machining of metals such as cutting, turning, grinding, milling and drilling. MWFs provide lubrication, cooling to the metal pieces during the machining and help to carry away the small debris such as swarf and fine metal particles that were generated by the machining of the metal. According to the Health and Safety Executive (HSE), MWFs could help increase the machining performance and extend the life of the cutting tools in addition to providing corrosion protection for the workpieces (HSE, 2011).

The National Institute of Occupational Safety and Health (NIOSH) in the U.S. stated that MWFs were available in different forms such as straight oil (neat oil), soluble oil (emulsifiable oil), semisynthetic MWFs and synthetic MWFs, and that workers could be exposed to MWFs through skin contact and inhalation during the machining process. Skin contact could occur when workers dip their hands into the fluid or handle tools or equipment covered with the liquid without using any personal protective equipment (PPE) such as gloves and aprons while inhalation exposure resulted from breathing MWF mists or aerosols in the air. Respiratory exposure could occur when the liquid splashes from the machine, leaving MWF aerosols suspended in the workers' environment and inhaled by them especially if they were not wearing the proper PPE and there was a lack of local exhaust ventilation to remove the MWF aerosols. The levels of the exposure were directly related to the proximity of the workers to the machine or the speed and pressure of the machine (Fishwich *et al.* 2015, NIOSH 2012, and NIOSH 1998).

More than 1,700 companies with around 540,000 employees are active in machinery and equipment sectors in Malaysia, and it is continuously growing in the future (MIDA 2014). Exposure to MWF aerosols or mists through inhalation could lead to adverse respiratory problems such as coughing, phlegm, wheezing, rhinitis, acute impairment of lung function and hypersensitivity pneumonitis (Lillienberg *et al.* 2010). Exposure to MWF aerosols through direct skin contact may lead to adverse skin condition such as contact dermatitis (Maizura *et al.* 2015, Brown 2003).

Perkins and Angenent (2010) stated that water-based MWFs in a machining factory bore significant bacterial growth in the fluids and aerosols which could cause adverse dermatological and respiratory effects among exposed workers.

Hypersensitivity pneumonitis (HP) was one of the consequences of respiratory exposure to MWFs, and it occurred among workers who had to handle water-based MWFs. It was found that the microbial contamination of MWFs was suspected to be the underlying agents for the HP (Burge, 2016, Rayan, *et al.* 2016, Barber, *et al.* 2014, and Lewis, *et al.* 2001).

HSE (2011) and Cherrie and Semple (2010) reported that all types of MWFs could irritate the skin or dermatitis, which could be resulted from bacteria and the toxic by-products when they were present in the sump through contact with sensitising agents and chemicals that were added to MWFs t bacteria.

One of the indicators for the exposure to the microbial contaminants of MWFs was the level of Immunoglobulin G (IgG) in the blood serum of the exposed workers against microbes identified from bulk samples of MWFs and air samples in the production division of the metal machining factory. This indicator was a practical tool for occupational health physicians to determine the microbial contaminants of MWFs (Maizura et al. 2015, Laitinen *et al.* 1999).

Prevention of the exposure to MWF aerosols or mists either through inhalation or direct skin contact would decrease the cases of respiratory and skin symptoms. NIOSH (2012) recommended an occupational safety and health programme to prevent and limit the exposure to MWFs and it consisted of four components; safety health training to potentially exposed workers, worksite analysis by applying a workplace monitoring programme which included routine environmental monitoring of dermal and inhalation exposures, hazard prevention and control through different patterns of prevention and control methods such as fluid maintenance, isolation of the operation, efficient ventilation system and periodic medical monitoring of the exposed workers.

The effectiveness of the intervention methods in limiting or preventing the exposure to MWFs among workers in the metal industry needed to be evaluated based on the decrease in respiratory or skin symptoms. Bracker (2003) stated that quantitative exposure assessment, qualitative observation of the workers, and the patients' return to work experiences were tools to evaluate the recommended exposure controlling methods.

1.2 Problem Statements

1.2.1 Problem Statement 1

The workers in the production department of the metal machining factory were running different metal machining machines such as turners and grinders in addition to assembly points in every single production line. During the turning and grinding, the workers were required to stop the machine and open the safety guard almost every 5 minutes to adjust the stone, close the guard and operate the machine, during which it would be highly contaminated with the MWFs. Besides that, workers in the assembly department worked with direct skin contact with the products and most of them were using their bare hands. Therefore, there was a high probability that the workers could have been exposed to the MWFs throughout their working period either through inhalation or direct skin contact that may lead to serious respiratory and skin problems (Burge, 2016, Barber, *et al.* 2014, and Suuronen, *et al.* 2008). Also, the factory was using water-based MWFs which provided a good environment for microbes to grow. On the other hand, the factory was producing materials made of stainless steel that contained chrome (Cr) and nickel (Ni), and these two metals usually melted due to the heat and friction during the machining process, thus integrated with the MWFs (Zailina *et al.* 2015). Exposure to Cr and Ni would aggravate the health effects of exposure to MWFs. Therefore, respiratory and skin exposure assessments were crucial among exposed workers in the production section to determine the level of exposure (Park, 2012 and Hodgson, 2004). The respiratory and skin health assessments were also essential to identify how the adverse health effects of the respiratory and skin exposure to MWFs could be limited. (Burge, 2016, Barber, *et al.* 2014 and Suuronen, *et al.* 2008).

1.2.2 Problem Statement 2

The factory setting included local exhaust ventilation (LEV) system and computer numerical control (CNC) machines, which were engineering control methods used to protect the workers. However, as mentioned in section 1.2.1, the production staff were at high risk of getting exposed to MWFs through various routes of exposure such as inhalation and direct skin contact when opening the safety guard of the turning and grinding machines in addition to assembly activities. The exposure to MWFs could occur especially when workers do not use any personal protective equipment (PPE) such as a face mask, gloves and towels provided by the factory management and wash hands properly to remove any fluid touched by the skin, change working uniforms immediately at the end of the shift (the administration provided a laundry unit for workers) and refrain from smoking. The main issue, in this case, was that the workers had a wrong perception of MWFs due to its water-based nature. Exposure to MWFs was perceived as harmless because the workers believed that the microbes in the MWFs were useful for preserving the pH level of the fluids and increase its shelf life. Bansal and Yadav (2016) stated that a large number of diseases among workers indicated that they were exposed to health hazards and they lacked the awareness of the health effects from being exposed to these materials. Joshi *et al.* (2016) and Salinas, *et al.* (2002) stated that enhancing the awareness of the workers could improve the occupational health and safety of the workers.

1.3 Research Justification

The workers in the production division were continuously exposed to MWFs throughout their working activities including grinding, turning and assembling. The exposure through inhalation or direct skin contact could lead to serious health effects on the skin and respiratory system (Burge, 2016, Barber, *et al.* 2014, and Suuronen, *et al.* 2008). Therefore, respiratory and skin exposure assessments were required among exposed workers in the production unit and unexposed workers were used as a reference (Park, 2012 and Hodgson, 2004). Also, determining the respiratory and skin health status was essential to identify how to limit the adverse health effects of the MWF exposure (Burge, 2016, Barber, *et al.* 2014 and Suuronen, *et al.* 2008). That would allow us to determine the respiratory and skin health status and level of respiratory, besides skin exposure to MWFs and its contaminants, and the factors that were associated with health symptoms and the level of exposure among exposed and unexposed workers. In the end, we would be able to identify the appropriate awareness programme that is capable of enhancing workers' awareness towards MWFs and its contaminants and improving their compliance with the preventive measures.

1.4 Contribution to Knowledge and Practice

The results of this study contributed to the pre-existing knowledge on respiratory and skin health effects due to exposure to MWFs and its contaminants Cr and microbes among workers in the metal machining factory. Also, the results revealed the information on the method of assessment of the following; respiratory exposure to MWFs and Cr, whole blood Cr level, identification of microbes in contaminated MWFs and evaluation of biomarkers (IgG) to specific microbes isolated from the MWFs.

Concerning the practical impact of the study, the results contributed to two knowledge gaps. The first was on skin exposure to MWFs and how to assess it by using the Dermal Exposure Assessment Method (DREAM) that was utilised for the first time in Malaysia and could be used as a reference for future researchers. This method was very precise and took into consideration of the activity of the workers to identify the path of the skin exposure, which could be through emission, deposition or transfer for every part of the body. The method also took the usage of PPE regarding the consistency of usage, type and quality of the equipment into account. Therefore, we believe this study could be a suitable reference for future researchers when assessing dermal exposure to liquid chemical hazards.

Additionally, the study results showed the effectiveness of the self-awareness programme in enhancing the metal machining factory workers' awareness on MWFs, which consisted of 90% water and 10% chemicals, and its health effects on the skin and respiratory system. The programme also aimed at enhancing the workers' compliance with practicing the preventive measures such as wearing appropriate face masks, and gloves, washing hands and forearms five times or more per day, cleaning the working area using disposable towels provided before any contact with the machines and changing uniforms immediately at the end of the working shift.

1.5 Conceptual Framework

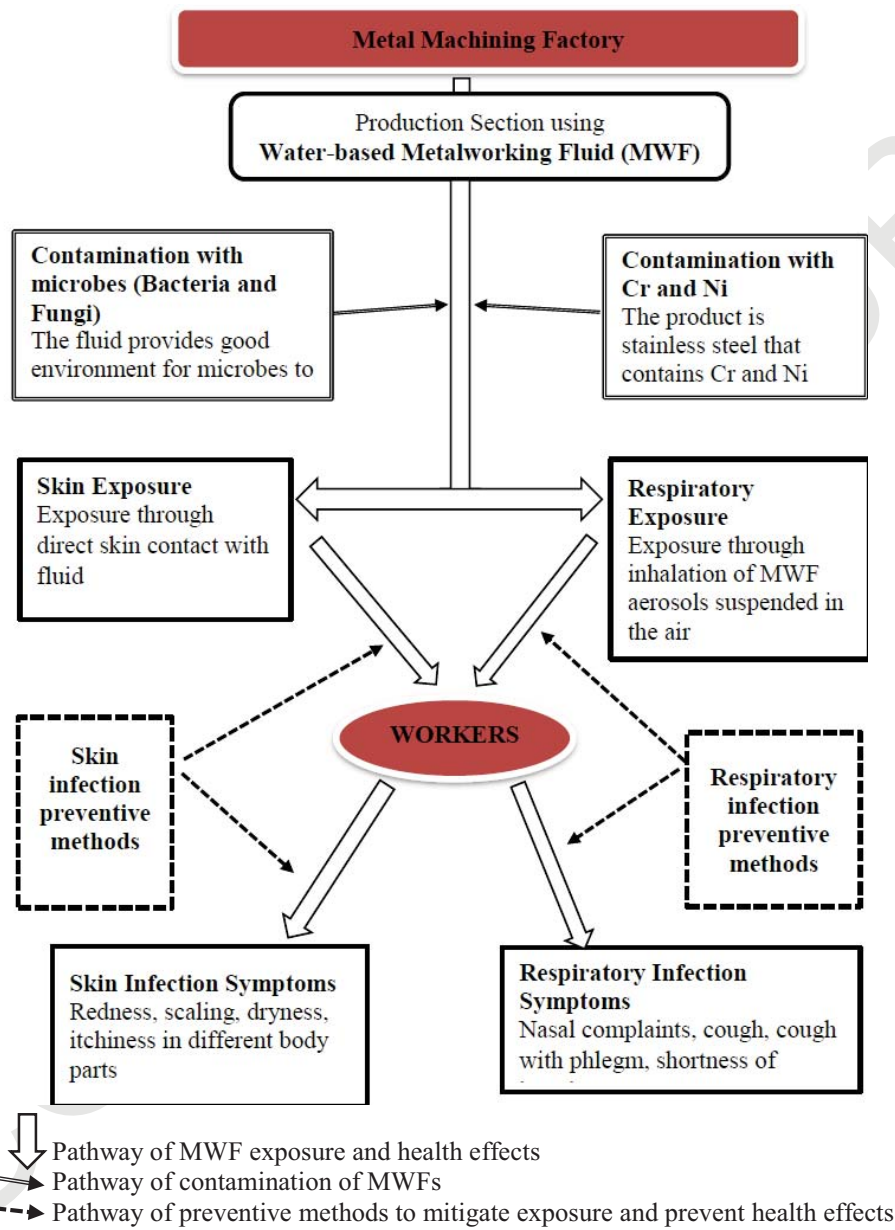


Figure 1.1: Conceptual Framework

1.6 Research Questions, Objectives, Hypotheses, Frameworks and Study flow

1.6.1 PHASE I

1.6.1.1 Phase I Research Questions

Among workers at the metal machining factory:

1. What are the prevalence rates of respiratory symptoms (nasal complaints, cough, cough with phlegm, shortness of breath) among MWF-exposed workers compared to unexposed workers?
2. What are the pulmonary function status (FEV₁, FVC, and FEV₁/FVC) of MWF-exposed workers compared to unexposed workers?
3. What are the prevalence rates of skin infection symptoms such as redness, scaling, dryness and itchiness on different body parts (head, neck, arms, forearms, hands, front torso, back torso and lower limbs) among MWF-exposed workers compared to unexposed workers?
4. What is the level of respiratory exposure to MWFs among exposed workers compared to unexposed workers?
5. What is the level of skin exposure to MWFs among exposed workers compared to unexposed workers?
6. What are the levels of respiratory exposure to Cr and Ni among exposed workers compared to unexposed workers?
7. What are the levels of whole blood Cr and Ni among exposed workers compared to unexposed workers?
8. What are the microbial (bacteria and fungi) species that inhabit the MWFs in the production division?
9. What are the levels of microbial (isolated from MWF) specific IgG in the blood serum of workers in the production division?
10. Are there associations between the selected factors (exposure, occupational characteristics and compliance with safety methods) and the prevalence of respiratory and skin symptoms reported?

1.6.1.2 General Objectives

To determine the prevalence rates of respiratory and skin symptoms between MWF-exposed workers compared to unexposed workers in a metal machining factory.

1.6.1.3 Specific Objectives

1. To determine the prevalence rates of respiratory symptoms (nasal complaints, cough, cough with phlegm, shortness of breath) among MWF-exposed workers compared to unexposed workers.
2. To determine the pulmonary function status (FEV₁, FVC, and FEV₁/FVC) of MWF-exposed workers compared to unexposed workers.
3. To determine the prevalence rates of skin infection symptoms such as redness, scaling, dryness and itchiness on different body parts (head, neck, arms, forearms,

- hands, front torso, back torso and lower limbs) among MWF-exposed workers compared to unexposed workers.
4. To compare the levels of respiratory exposure to MWFs among exposed and unexposed workers.
 5. To compare the levels of skin exposure to MWFs among exposed and unexposed workers.
 6. To compare the levels of respiratory exposure to Cr and Ni among exposed and unexposed workers.
 7. To compare the levels of whole blood Cr and Ni among exposed and unexposed workers.
 8. To determine the microbial (bacteria and fungi) species inhabiting the MWFs in the production division.
 9. To determine the level of microbial (isolated from MWF) specific immunoglobulin G in the serum of the production division workers.
 10. To determine the relationship between selected factors (exposure, occupational characteristics, and compliance with safety methods) and the prevalence of respiratory and skin symptoms reported.

1.6.1.4 Hypotheses

1. The prevalence rates of respiratory symptoms (nasal complaints, cough, cough with phlegm, shortness of breath) of MWF-exposed workers are higher compared to unexposed workers.
2. The pulmonary function status (FEV₁, FVC, and FEV₁/FVC) of MWF-exposed workers is lower compared to unexposed workers.
3. The prevalence rates of skin symptoms such as redness, scaling, dryness and itchiness on different body parts (head, neck, arms, forearms, hands, front torso, back torso, lower limbs) of MWF exposed is higher compared to unexposed workers.
4. The level of respiratory exposure to MWFs among exposed workers is higher compared to unexposed workers.
5. The level of skin exposure to MWFs among exposed workers is higher compared to unexposed workers.
6. The levels of respiratory exposure to Cr and Ni among exposed workers is higher compared to unexposed workers.
7. The levels of whole blood Cr and Ni among exposed workers is higher compared to unexposed workers.
8. The majority of microbial (bacteria and fungi) species inhabiting the MWFs within the production division is gram-negative bacteria.
9. The level of microbial (isolated from MWFs) specific immunoglobulin G in the serum of workers in the production division is positive.
10. There were associations between the selected factors (exposure, occupational characteristics, and compliance with safety methods) and the prevalence of respiratory and skin symptoms reported.

1.6.1.5 Phase I Study flowchart

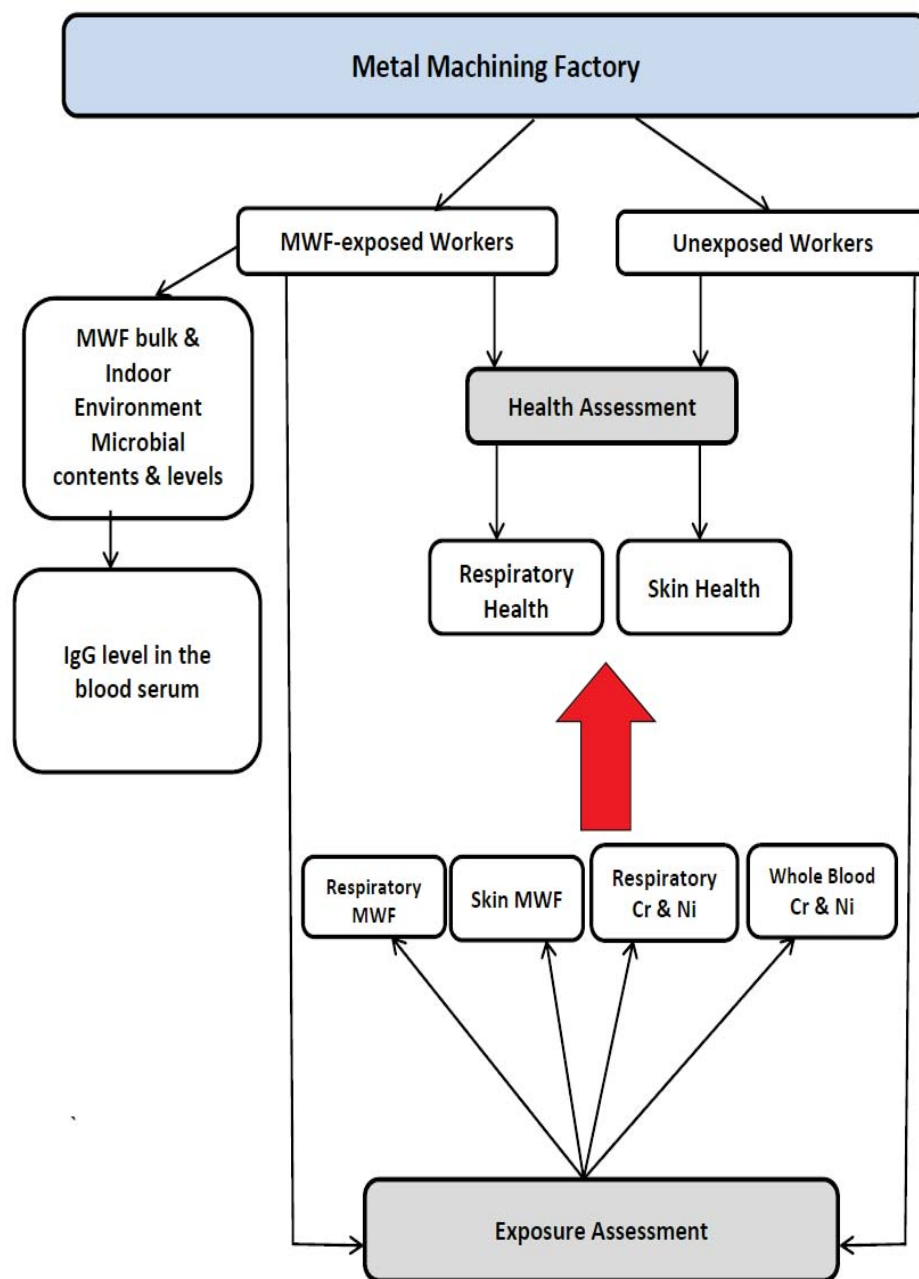
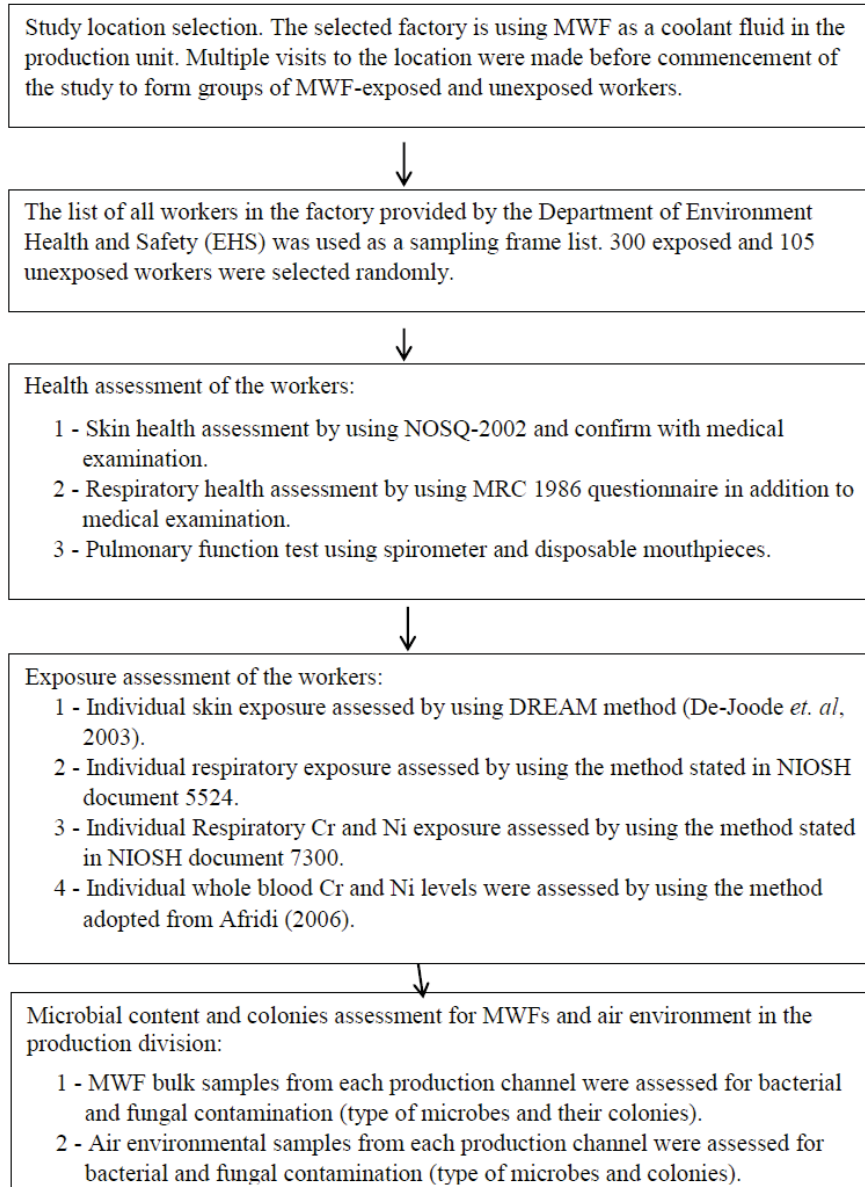


Figure 1.2: Framework Phase I

1.6.1.6 Phase I Study Flow

The chart below is to summarise the flow, setting, required analysis and method of assessment during Phase I of the study.



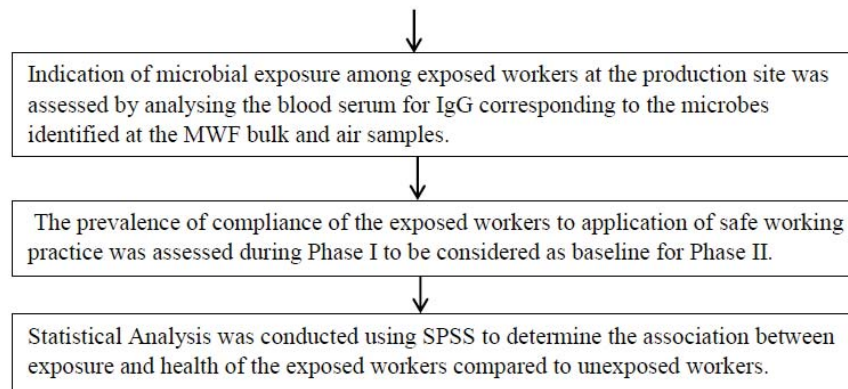


Figure 1.3: Study flow chart Phase I

1.6.2 PHASE II

1.6.2.1 Phase II Research Questions

1. What is the level of differences (between pre and post intervention) in the prevalence rates of respiratory symptoms (nasal complaints, cough, cough with phlegm and shortness of breath) among the intervention and control groups?
2. What is the level of differences (between pre and post intervention) in pulmonary function status (FEV₁, FVC, and FEV₁/FVC) among the intervention and control groups?
3. What is the level of differences (between pre and post intervention) in the prevalence rates of skin symptoms such as redness, scaling, dryness and itchiness on different body parts (head, neck, arms, forearms, hands, front torso, back torso and lower limbs) among the intervention and control groups?
4. What is the level of differences (between pre and post intervention) of skin exposure to MWF among the intervention and control groups?
5. What is the level of differences (between pre and post intervention) in the prevalence rates of using preventive measures (wearing a face mask and gloves, cleaning working area, washing hands, changing uniform and avoiding cigarettes) among the intervention and control groups?

1.6.2.2 General Objectives

To evaluate the effectiveness of the intervention programme in preventing the adverse effects of MWF exposure on respiratory and skin health among workers in the metal machining factory.

1.6.2.3 Specific Objectives

1. To determine the level of differences (between pre and post intervention) in the prevalence rates of respiratory symptoms (nasal complaints, cough, cough with phlegm and shortness of breath) among the intervention and control groups.
2. To determine the level of differences (between pre and post intervention) in the pulmonary function status (FEV_1 , FVC, and FEV_1/FVC) between the intervention and control groups.
3. To determine the level of differences (between pre and post intervention) in the prevalence rates of skin symptoms such as redness, scaling, dryness and itchiness on different body parts (head, neck, arms, forearms, hands, front torso, back torso and lower limbs) among the intervention and control groups.
4. To determine the level of differences (between pre and post intervention) of skin exposure to MWFs among the intervention and control groups.
5. To determine the level of differences (between pre and post intervention) in the prevalence rates of using preventive measures (wearing a face mask and gloves, cleaning working area, washing hands, changing uniforms and avoiding cigarettes) among the intervention and control groups.

1.6.2.4 Hypotheses

1. The level of differences (between pre and post intervention) in the prevalence rates of respiratory symptoms (nasal complaints, cough, cough with phlegm and shortness of breath) in the intervention group is higher compared to the control group.
2. The level of differences (between pre and post intervention) in the pulmonary function status (FEV_1 , FVC, and FEV_1/FVC) in the intervention group is higher compared to the control group.
3. The level of differences (between pre and post intervention) in the prevalence rates of skin symptoms such as redness, scaling, dryness and itchiness on different body parts (head, neck, arms, forearms, hands, front torso, back torso and lower limbs) in the intervention group is higher compared to control group.
4. The level of differences (between pre and post intervention) of skin exposure to MWFs in the intervention group is higher compared to the control group.
5. To determine the level of differences (between pre and post intervention) in the prevalence rates of using preventive measures (wearing a face mask and gloves, cleaning working area, washing hands, changing uniforms and avoiding cigarettes) within the intervention group is higher compared to control group.

1.6.2.5 Phase II study flowchart

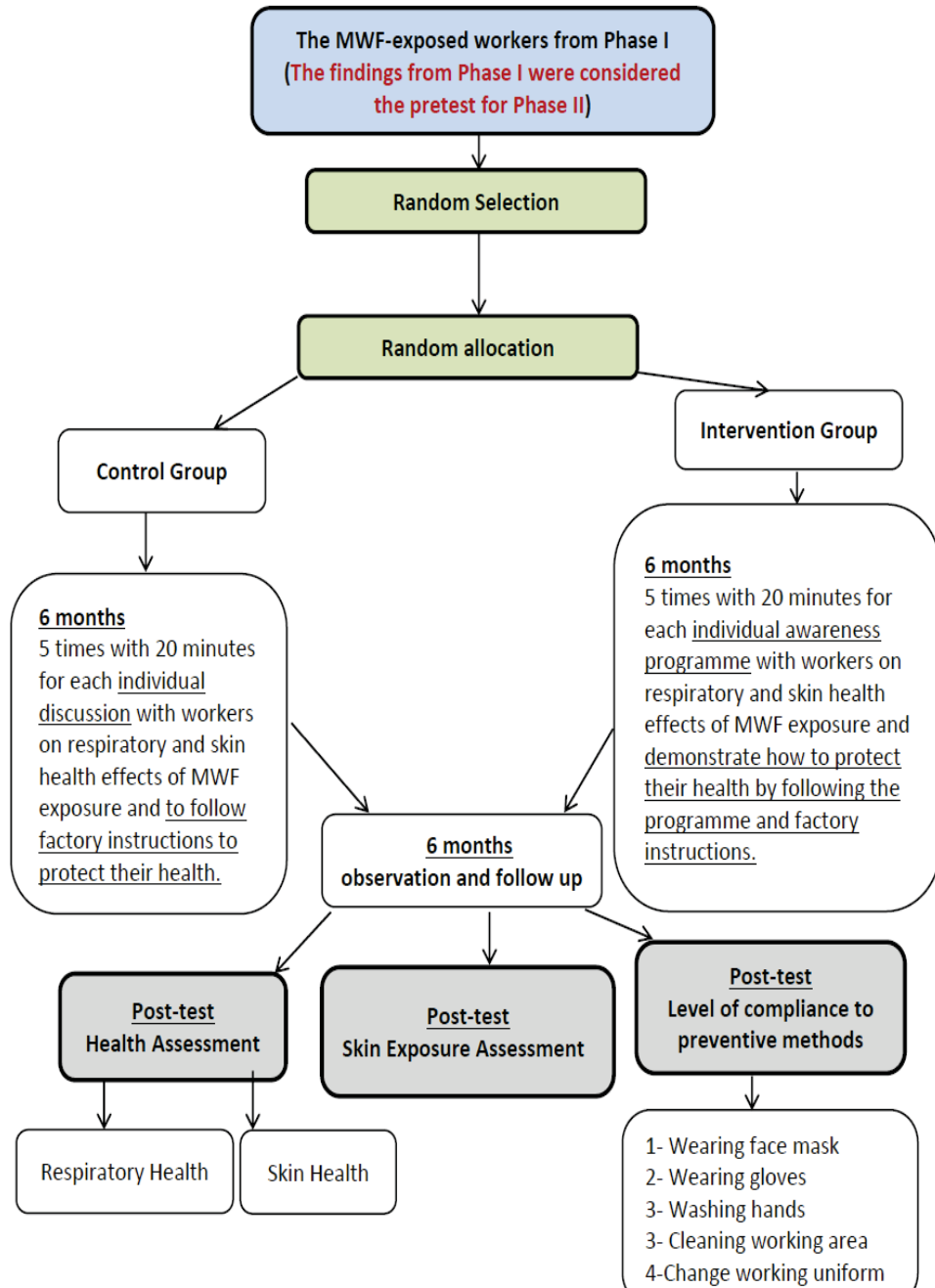
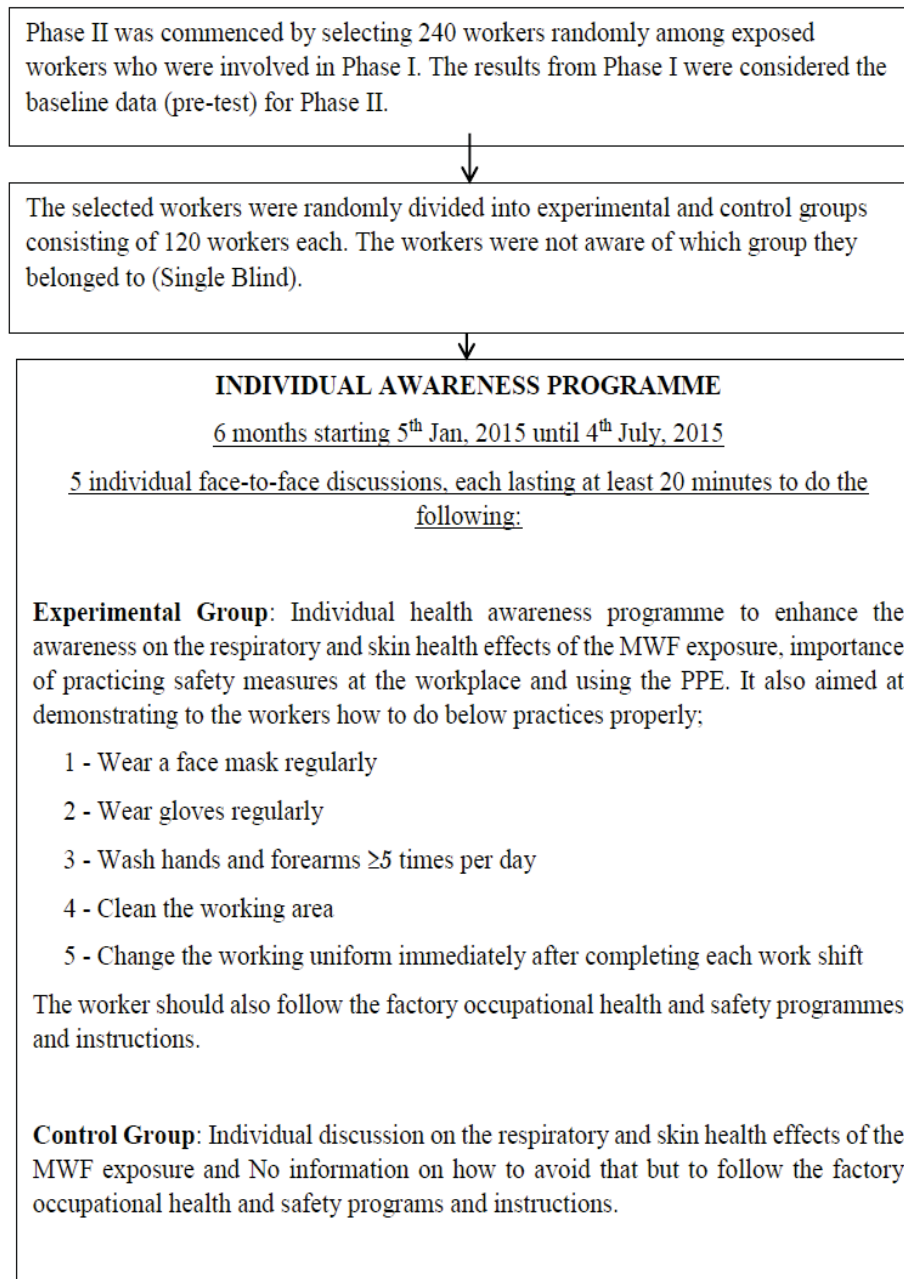


Figure 1.4: Framework Phase II

1.6.2.6 Phase II Study Flow

Study flow is to summarise the flow, setting, required analysis and method of assessments will be followed during Phase II of the study.



I

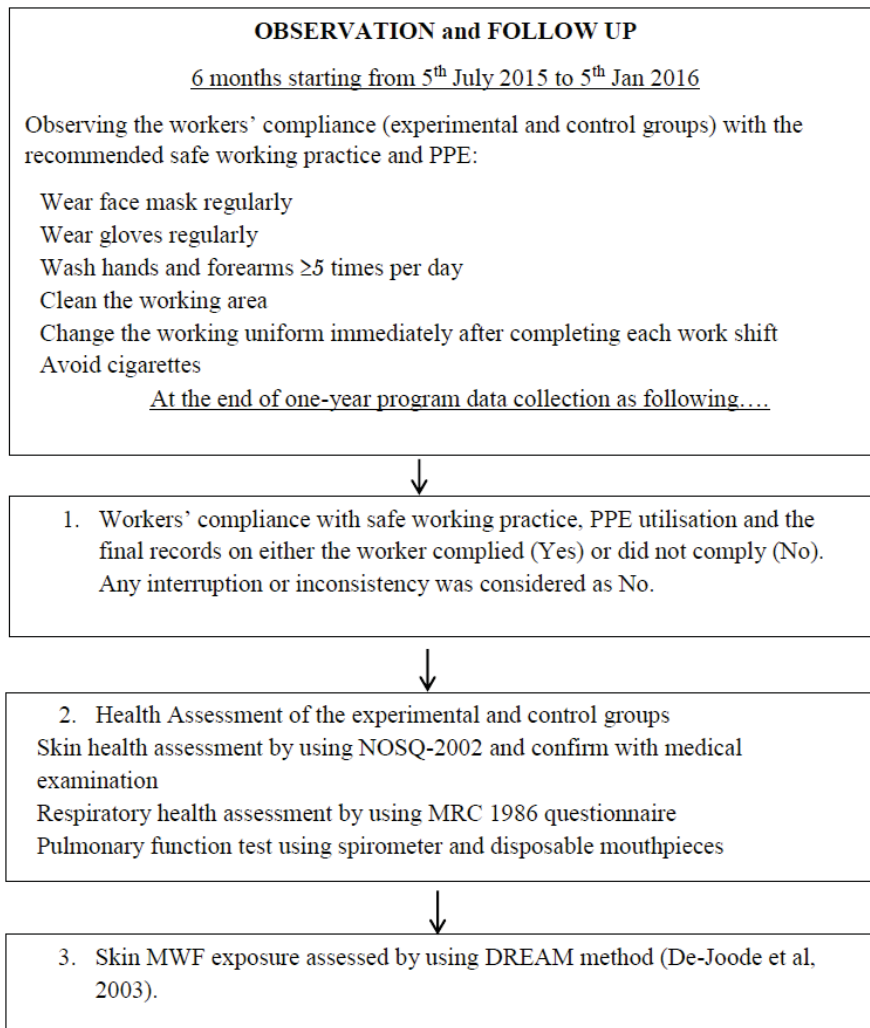


Figure 1.5: Study flow chart Phase II

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