# INFLUENCE OF PERSONAL ATTRIBUTES AND EMPLOYMENT AND WORK FACTORS ON WORK INJURIES AMONG WELDERS

*A thesis submitted to Cochin University of Science and Technology*

*in partial fulfillment of the requirements*

*for the award of the degree of*

**DOCTOR OF PHILOSOPHY**

*Under the faculty of Engineering*

*By*

**MAHESA RENGARAJ R**

**(Reg.No:3537)**

*Under the Supervision of*

**Prof. (Dr.) M.N.Vinodkumar**

**DIVISION OF SAFETY AND FIRE ENGINEERING**
**SCHOOL OF ENGINEERING**
**COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY**
**KOCHI – 22, KERALA, INDIA**

*June 2016*

*Influence of Personal Attributes and Employment and Work Factors on Work Injuries among Welders*

*Ph.D. Thesis*

*Author:*

*Mahesa Rengaraj.R*
*Division of Safety and Fire Engineering*
*School of Engineering*
*Cochin University of Science and Technology*
*Kochi-682022, Kerala, India*
*Email: mahes24h@gmail.com*

*Supervisor:*

*Prof. (Dr.) M.N.Vinodkumar*
*Professor*
*Division of Safety and Fire Engineering*
*School of Engineering*
*Cochin University of Science and Technology*
*Kochi-682022, Kerala, India*
*Email: mnvinodk@gmail.com*

*June 2016*

*Dedicated to……*

*My Parents*

*Late T.Raman*

*&*

*Late N.Sarojini*

# *Certificate*

*Certified that this thesis entitled "INFLUENCE OF PERSONAL ATTRIBUTES AND EMPLOYMENT AND WORK FACTORS ON WORK INJURIES AMONG WELDERS", submitted to the Cochin University of Science and Technology, Kochi for the award of Ph.D. Degree under the Faculty of Engineering, is the record of bonafide research carried out by **Mr. Mahesa Rengaraj.R.** under my supervision and guidance at School of Engineering, CUSAT. This work did not form part of any dissertation submitted for the award of any degree, diploma, associateship, fellowship or other similar title or recognition from this or any other institution.*

***Kochi – 22*** <br> *03.06.2017*

***Prof. (Dr.) M.N. Vinodkumar*** <br> *Supervising Guide*

# *Declaration*

*I hereby declare that the work presented in the thesis entitled "INFLUENCE OF PERSONAL ATTRIBUTES AND EMPLOYMENT AND WORK FACTORS ON WORK INJURIES AMONG WELDERS" is based on the original work done by me under the supervision of Prof. (Dr.) M.N.Vinodkumar, Division of Safety and Fire Engineering, School of Engineering, Cochin University of Science and Technology. No part of this thesis has been presented for any other degree from any other institution.*

*Kochi-22* *Mahesa Rengaraj.R*
*03-06-2017* *Reg. No: 3537*

# Acknowledgement

I am highly indebted to Prof. (Dr.) M.N.Vinodkumar, Professor, Division of Safety and Fire engineering for inspiring and guiding me throughout my research work. Without his kind consideration and guidance, I would not have been able to achieve the milestone.

I also take this opportunity to express a deep sense of gratitude to Prof. (Dr). G Madhu, Principal, School of Engineering, Cochin University of Science and Technology, for his cordial support, which helped me in completing this research work through various stages.

I also take this opportunity to express a deep sense of gratitude to my teachers Dr. Dipak Kumar Sahoo, Dr George Mathew, Dr V.R. Renjith, and A. Nirmal Job, Division of Fire and Safety engineering, School of Engineering, Cochin University of Science and Technology, for their cordial support which helped me in completing this task through various stages.

It is with sincere gratitude that I wish to thank all my colleagues, for their encouragement and unconditional support. I convey my sincere thanks to all the teaching and non-teaching staff of Cochin University of Science and Technology and SCMS School of Engineering Technology for their help during my research work. I convey my sincere thanks to the family of Bharat Heavy Electrical Limited and their associated ancillary industrial fabrication estates for their help in completing the survey questionnaire.

I would like to appreciate all the researchers whose works I have used, initially in understanding my field of research and later for the updates.

I take this opportunity to dedicate this work to my late parents who have made me for what I am and my family who had given consistent support throughout my research work

**Mahesa Rengaraj.R**

## ABSTRACT

Technological improvement in every occupation has reduced the extent of work injuries in developed countries. These facilities are not available to an average worker employed in a developing country. This aspect is very common with welders performing manual metal arc welding process in the industrial fabrication environment. The personal attributes, employment factors and work factors interact with each other in a controlled environment. At certain occasions, the control is lost that leads to work injuries. These work injuries are of two types less frequent highly severe and highly frequent and less severe in character. As the injury severity increases, reporting increases and details are readily available in the source records of the hospital or firm. However, as the injury severity decreases the frequency of reporting decreases and the related records become scarce. In this background, the present study is undertaken to decipher influential personal attributes, employment factors, work factors on non reported highly frequent and less severe work-injuries and musculoskeletal disorders among manual metal arc welders.

In presence of a variety of energy interactions with various factors in the fabrication environment, manual metal arc welders face numerous varieties of work injuries. In many occasions during industrial fabrication work, manual metal arc welders are subjected to frequent first degree work injuries, which are treated with first aid. These work injuries cause pain that are not reported, which in turn causes morbid state among welders during their work leading to reduced productive effort. Any form of pain is a deviation from healthy state of welder that deters his effective productive effort.

Initially, a questionnaire was formed with personal attributes, employment and work factors identified from literature survey to measure pain frequencies due non reported highly frequent and less severe work injuries and standardised Nordic questionnaire was used to measure musculoskeletal disorder pain among manual metal arc welders. The questionnaire was empirically validated through statistical analysis. ANOVA test performed to find the influence of personal attributes on pain frequencies shows age as a significant factor. The one sample 't' test and independent sample 't' test reveals pain frequencies between welder population and welders employed by organised and unorganised sector firms are different. Independent sample 't' test performed to test the influence of employment factor levels and pain frequencies reveal extended working hours, welders engaged in shift work, nature of employment, mode of apprenticeship training and lower physical work load influence pain frequencies due to non reported highly frequent less severe work injuries among the welder population.

Multiple regression analysis was modeled to find the influence of work factor domain on pain frequencies due to non reported highly frequent and less severe work injuries. The result reveals health perception, safety culture and social environment influence pain frequencies in welder population and welders employed in organised and unorganised sector fabrication firms.

Binary logistic regression was performed to find the influential personal attributes and employment factors on musculoskeletal disorder pain in welders body region for weekly prevalence, annual prevalence and annual disability. The result shows shift work influence musculoskeletal disorder pain in shoulder region for weekly and annual prevalence. Tests further reveal shift work as a factor influence annual disability due to musculoskeletal disorder pain in neck, shoulder, upper and lower back regions. Physical workload influence annual disability due to musculoskeletal disorder pain in wrist/hands and upper back region. Working hours influence musculoskeletal disorder pain that causes annual disability in lower back region. The identified factors can be considered as points from where intervention initiatives can be focused to mitigate work injuries among welders.

Keywords: welder, non reported highly frequent less severe work injuries, independent sample t-test, one sample t-test, binary logistic regression, welders physical workload

## *Contents*

*Title* *Page No*

# LIST OF FIGURES

# LIST OF TABLES

# Abbreviations

| | | |
|---|---|---|
| AEA | - | Action Error Analysis |
| BHEL | - | Bharat Heavy Electrical Limited |
| CCOHS | - | Canadian Centre for Occupational Health and Services |
| CFA | - | Confirmatory Factor Analysis |
| CFI | - | Comparative Fit Index |
| CSA | - | Cause Sequence Analysis |
| CSO | - | Central Statistical Organisation |
| EF | - | Employment Factor |
| EFC - | - | Engineering Fabrication Cluster |
| ETA | - | Event Tree Analysis |
| FMEA | - | Failure Mode Effective Analysis |
| FMECA | - | Failure Mode Effect and Criticality Analysis |
| FTA | - | Fault Tree Analysis |
| GDP | - | Gross Domestic Product |
| HAVS | - | Hand Vibration Syndrome |
| HEPI | - | Human Error Probability Index |
| HP | - | Health Perception |
| ICECI | - | International Classification for External Cause of Injuries |
| ICMR | - | Indian Council for Medical Research |
| ILO | - | International Labour Organization |
| LUBA | - | Postural Loading on Upper Body Assessment |
| MoL | - | Ministry of Labour and employment |
| MSD | - | Musculoskeletal Disorder |
| MTC | - | Mental Task Content |
| MVNQ | - | Modified Version of Nordic Questionnaire |
| NCMH | - | National Commission on Macroeconomics and Health |
| NCRB | - | National Crime Records Bureau |

| | | |
|---|---|---|
| NIOSH | - | National Institute of Occupational Safety and Health |
| NNFI | - | Non-Normed Fit Index |
| NRHFLS | - | Non Reported Highly Frequent less Severe |
| OHS | - | Occupational Health Services |
| OJT | - | On-the Job Training |
| OSF | - | Organised Sector Fabrication |
| PA | - | Personal Attribute |
| PE | - | Physical Environment |
| PRA | - | Probabilistic Risk Assessment |
| PTC | - | Physical Task Content |
| QEC | - | Quick Exposure Checklist |
| RULA | - | Rapid Upper Limb Assessment |
| SC | - | Safety Culture |
| SE | - | Social Environment |
| SLIM | - | Success Likelihood Index Method |
| SME | - | Small and Medium Scale Enterprise |
| SSIA | - | Small Scale Industry Association |
| TE | - | Technical Environment |
| TLI | - | Tucker Levis Index |
| USF | - | Unorganised Sector Fabrication |
| WFA | - | Work Factor Analysis |
| WFD | - | Work Factor Domain |
| WHO | - | World Health Organization |
| WRMSD | - | Work Related Musculoskeletal Disorder |

*Chapter* **1**

# INTRODUCTION

Contents



## 1.1 ACCIDENT AND WORK INJURIES

Manual metal arc welding is a high temperature process in fabrication industry, which leads to varieties of work related injuries. Any production activity deals with different kinds of force and energy interactions in a controlled environment. On certain occasions, this control is lost and uncontrolled energy transfer takes place leading to work injury incidents. Accidents and injuries are undesirable outcomes of any work environment. Factors responsible for work injuries are multifaceted in an industrial setting. This present study attempts to find out the personal attributes, employment factors and work factors that influence pain frequencies caused due to non reported highly frequent less severe work injuries and pain caused due to musculoskeletal disorder among welders employed in a cluster of fabrication firms. Thus, the thesis aims at accomplishing this objective for which detailed methodology is laid out.

## 1.2 THEME

Work injury is a preventable health problem among working communities where every injury is a result of an incident termed as an accident. Injury is a body lesion that results from acute over exposure of energies interacting with the body in amounts and rates that exceeds threshold of physiological tolerance (ICECI, 2004).

In safety and injury research literature, inconsistencies and overlap prevails in the usage of terms accident and injury. Many research articles set to analyze accident, in fact end up in investigating injuries (Langley, 1988). Research articles in injury and accident causation are largely overlapping and have many commonalities. Analyzing the published literature of past three decades of accident research shows the need to delineate injury research from accident research (Mckenna, 1983; Robertson, 1998). Causal models developed for accident analysis is partially applicable to injury incidents. However, accident theories explaining accident causation are well received in the literature and no theories have been classified as injury theories (Khanzode et al., 2012). Moreover, indicators of the work injury databases is based on fatal injuries, that is ambiguous to serve the low to high injury severity continuum and in turn depicts only a part of the work injury magnitude in databases (Anne and Ann, 2004. p.88). Workers employed in steel and its related industries are at the greater risk for non fatal work injuries and illness due to high temperature process involved in making the product (Jovanovic et al., 2004).

Advancing technology in the field of accident research has undergone an unbelievable transformation in their scope and depth. There is an increased acceptance of the view that injury is not an accident, a change in thought viewing accident as fatal injuries (Anne and Ann, 2004). Last four decades of injury, research shows that work related injury is predictable, preventable and treatable while risk severity and injury outcome is modifiable for effective interventions.

The accident causation models that investigate complex system level accidents are suitable for analyzing event chains that percolate from component level to system level failures that result in accidents with low priority for injury incidents. Event chains that explain less frequent highly severe work injury exposures are more oriented towards process industries. In viewpoint of injury research, highly frequent less severe work injury exposures are critical in manufacturing industries due to repetitive nature of work. This study focuses on exploring the factors that influence pain frequencies caused due to Non Reported Highly Frequent Less Severe (NRHFLS) work injuries among manual metal arc welders employed by firms in an Engineering Fabrication Cluster (EFC) in India.

## 1.3 INDIAN SCENARIO ON WORK INJURIES

In the Indian context, XVII World Congress on Safety and Health at Work organized by ILO-2008 invited Indian labour secretary to speak on strategies and program for safety and health in the future. Though he spoke on Indian government's future policies towards commitment on health and safety issues at work, it was devoid of any statistical representation (The Hindu April $19^{th}$ 2000). The speech showed the dismaying health and safety record in India. The prime cause of work injuries among Indian working population is unsafe working condition that lacks single regulatory monitoring authority, recording of deviation in safety practices and absence of work injury surveillance (Gururaj, 2005). The standard estimates calculate growth rates based on GDP index on quarterly basis, but it is painful to state that numbers of dying and ailing workers who make this growth possible are not recorded nor discussed. ILO compilation is the only source to recognize the magnitude of work injuries. The estimates show that around 403,000 people in India die every year due to work related problems (ILO, 2013). The importance of scale is that more than 1,000 workers die every day from work related diseases, which accounts for 46 death every hour. No single Indian work injury database provides details for work related death or death due to a particular reason (NCMH, 2005).

The National Crime Records Bureau (NCRB) is the principal nodal agency under the Ministry of Home Affairs, Government of India, and is responsible for the collection, compilation, analysis and dissemination of injury related information (NCRB 2001a, 2001b). The absence of centralized agency in India makes it difficult to examine the extent of work related injuries. Workers are exposed to many hazards that result in fatal and non fatal injuries varying between low and high severity continuum. Traditionally, work injury deaths are considered under general medical conditions and the underlying causes are not documented and reported. Hence, the precise extent of work injuries is difficult to establish (Gururaj, 2005).

It is relevant to discuss issues related to work related injuries, as India is in transition phase in major areas like socio demographic, epidemiological and technological entities. Media and education have changed political, economic and social thinking that has impact on the health scenario. Last two decades has witnessed rapid urbanization, motorization, industrialization and migration of people, an indication that demonstrates socio-economic growth and its development. With the advent of mechanization and technology revolution, traditional ways of thinking, living and working have changed. Further, work injury causation factors are linked to social, environmental, cultural and biological issues viewed as the result of socio-demographic transition. Prevention and mitigation of work injuries are the major challenges faced by Indian industries today.

Some of the statistical inputs about work injuries in India: Agriculture is the main activity of Indian economy and half of the total work force is employed in the agriculture sector. A study on farming accident estimate reveals annual mortality rates of 22 per 100,000 farmers (Nag and Nag, 1998). High level of respiratory morbidity was found among mango plantation workers in Lucknow, the reason being inhaling organic dust during farming operations (Gupta et al., 1995). Regulatory legislation prohibits paid work for child below 14 years, but estimates of 75 to 115 million children are being the part of the work force (Nag and Nag, 1998). In addition, child labors accounts for 80 % of the work force in India (Mathews et al., 2003). A study on three districts in West Bengal among agriculture labourers reveals heat induced stress, mechanical injuries, insect bites and toxicity of chemicals used in the paddy fields contribute to major cause of occupational morbidity (Banerji, 1993). High levels of respiratory morbidity due to inhalation of cotton dust has been reported among child labours employed in carpet weaving industry in Jaipur (Joshi et al., 1994). A report on workers employed leather industries indicate acute physical pain due to working in awkward postures for long working hours as work related risk factor (Mitra, 1993). Workers employed in manufacturing crackers in Sivakasi apart from fire and explosions experience cough, dizziness, inhalation of chlorate and sulphate dust, eye infection and asthma in their work place (Mitra, 1994). A survey indicates presence of high nicotine content in tobacco workers urine sample as the cause of severe physical inability (Ghosh et al., 1979). An occupational morbidity of 25% has been recorded in tannery slums in Kanpur industrial area (Shukla et al., 1991). A report on lock manufacturing factory shows an increased respiratory morbidity among workers employed in long working hours (Hassan et al., 2002). A survey on incense stick manufacturing units in Bangalore by Indian Council of Medical Research (ICMR) indicates respiratory morbidity among workers are due to inhaling of pollutants and suggests for a combined approach to tackle the occupational morbidity (Ratnakara et al., 1992). A review report on southeastern coalmines accounts for presence of pneumoconiosis up to 3 percent among the employed workers (Parikar, 1997). A report on Tamil Nadu asbestos industries shows a decreasing lung function due to inhaling of pollutants among asbestos workers (Gautam et al., 2003). Presence of byssionsis upto 3% is reported among workers employed in hosiery units in Tirpur (Muralidhar et al., 1995). Reported injury records in Indian Oil Corporation indicate that out of reported injuries, 35% of the injuries were work related and in that 6% accounted burns as the cause (Sarma, 2001).

More Indians perish due to three types of injuries at workplace: fatal injuries, non fatal physical injuries and health effects caused by environmental exposures. Fatal accident figures estimates are in the range of 50,000 to 75,000 per year while, non fatal accident figures varies five to seven million per year for the entire workforce in India (MoL, 2012). Analyzing mortality rate in the above population in the age group 15 – 60 years workplace fatalities contributes to premature death in the population to an extent of 5% (Central Statistical Organization, 2004). An incidence rate of industrial work injuries among employed workers is 9 per 1000, in a frequency of 2.6 per 100,000 man days work in India (ILO, 2013). A recent study by WHO in metropolitan areas of Delhi, reveals that out of total injuries reported 2% were work related (WHO, 2003b). A longitudinal study of 12,189 agricultural workers employed in Madhya Pradesh during 1995–99, reveals a incidence rate of 1.25/1000 workers/year (Tiwari et al., 2002). A survey on 2682 workers employed by oil refinery in Assam reports 35% of the total injuries occurred at the workplace (Sharma et al., 2001). A statistical report by NCRB (2001a, b) reveals 667 fatal accidents in 1999 due to factory/machine related accidents in Indian manufacturing sector. It also reports fatal work injuries related to specific occupational categories like 446 deaths in mine/quarry accidents, 220 deaths due to leakage of poisonous gasses, several work related deaths in traffic accidents and 2346 deaths due to the collapse of structures. In India, 25% of children are employed in hazardous places especially in rural areas, slums and in the unorganized urban labor sector (Mathur and Sharma, 1988). Community and hospital based studies in India reveal that nearly 10% – 15% of work injuries occur among children (Malhotra et al., 1995). The facts discussed above makes it necessary to address work injury issues in Indian work places.

## 1.4 RESEARCH ISSUES

Work injuries are unintentional injuries that occur in the work place that causes chronic or acute injury exposure. In any Industrial setting or productive work environment, work injuries are inevitable part of the conversion process but can be diligently prevented and managed. The accident and work injury literature draws the knowledge base from diverse disciplines that lead to many commonalities and overlapping areas in work injury studies. In addition, they rely on work injury databases that contain information on reported work injuries that are less frequent and highly severe. This shows work injury information depends on magnitude of severity. As work injury severity decreases, the reporting also decreases. In addition, lack of comprehensive data on work injury surveillance from organized and unorganized sector imposes limitations on injury studies. Studies in accident and work injury literature often consider reported less frequent highly severe work injuries that are more common to chemical and process industries. However, in manufacturing industry highly frequent less severe work injuries are important due to repetitive nature of jobs. Analyzing the work injuries of this nature can reveal the injury patterns useful for initiating intervention efforts (Khanzode et al., 2012). Given these reasons, for workers employed in manufacturing industry experience traumatic work injuries that is highly frequent less severe in its appearance due to repetitive characteristic of the jobs. At present, there is scarcity of literature that models and controls recurring nature of operational hazards in the work systems and factors responsible for causing it. Although rich literature is available for evaluating risks of catastrophe causing hazards, a research gap exists for quantification of occurrence removal, recurrence characteristics of factors that influence work injuries. As the factors influencing hazards are the roots of injury event chain, a study that characterize factors influencing work injury can be the first step towards modeling work injury risk.

In manufacturing environment specific to industrial fabrication sector, welders form the dominant group. Manual metal arc welding is a process that uses temperature and pressure to join two metal pieces. Due to high temperature energy interactions and presence of inherent process hazards associated with welding it is considered as a physically demanding job for welders. During a weldment process, welders are susceptible to many types of work injuries whose severity depends on factors in the work environment as well as the personnel involved in executing it. In certain occasions, welders experience pain caused due to highly frequent less severe work injuries that is commonly treated with first aid or left for self healing and are not generally reported. Any work injury for a welder is related with pain which is an undesirable outcome that is considered as deviation from healthy state and also influence morbidity during the welding work. This morbidity promotes an effect on their effective productive effort that relates with presenteesim phenomenon (present for work with ill health).

Over years personal attributes: age, experience; employment factors: working hours, extended working hours, shift work, permanent recruitment, adhoc recruitment, trade knowledge acquired through institution, trade knowledge acquired on-the-job training and work factors in the work environment have been examined in work injury studies that considers reported less frequent highly severe work injuries in varied occupations. However, work injury studies examining these factors considering non reported highly frequent less severe work injuries are scarcely reported in accident and work injury literature.

In Indian context, for total employed population, agriculture is the main activity followed by manufacturing, retail trade and other activities. Work injury surveillance is in the infant stage and absence of centralized agency makes it difficult to examine the work injuries related to specific industrial setting. Indian workers who are exposed to work related hazards are listed under general medical conditions where underlying causes are neither properly documented nor reported (Gururaj, 2005). Recent industrialization and globalization has more impact on work related morbidity among Indian workers. Traditional labour oriented markets are changing and at the same time general awareness message about work safety and environment hazards are not spread in the society (Iman, 2004). Besides developing countries like India have unique characteristics, that differentiate from developed countries in terms of high growth rate, large population density and poor literacy rates. Seventy percent of the total population is economically active in agriculture and employment in unorganized sector contributes to sixty percent of the gross domestic product. Further existing compliance and regulatory mechanism, lack of work injury surveillance and absence of unified reporting of work injury incidents favours comparing occupational and safety estimates with developed countries. All these notions suppress the magnitude of work injury estimates in India (Hital, 2008).

In this background, the present study is attempted on welders who form an important occupational group, owing to rapid urbanization and industrialization in India. Published literature identifies factors like personal attributes, employment factors and work factors that influence work injuries of reported nature in varied occupations. But, studies related to these factors influencing work injuries of non reported nature are scarce in welder related studies. Welders employed in fabrication industry are exposed to pain caused due to highly frequent less severe work injuries for example, a first degree burn due to high temperature energy interactions in a welding process. In many circumstances, these types of work injuries are not reported but in some occasions, these work injuries are treated with first aid or left for self healing. Any injury to a welder by nature is certain to cause pain, a deviation from healthy state that influence morbidity, which in turn deters his effective productive effort in work place.

The study investigates the following issues:

- What are the determinant personal attributes that influence pain frequencies caused due to non reported highly frequent less severe work injuries among welders?

- What are the determinant employment factors that influence pain frequencies caused due to non reported highly frequent less severe work injuries among welders?
- What are the determinant work factor domains that influence pain frequencies caused due to non reported highly frequent less severe work injuries among welders?
- What are the personal attributes and employment factors that influence musculoskeletal disorder pain in the welders body regions?

By finding out these influential factors, the intervention efforts can be directed to mitigate pain caused by non reported highly frequent less severe work injuries among welders.

## 1.5 OBJECTIVE OF THE THESIS

Given research issues identified in the previous sections the following objectives are framed.

- To develop and validate an instrument framework to identify and measure:
    - The pain frequencies caused due to non reported highly frequent less severe work injuries treated with first aid
    - Personal attributes
    - Employment factors
    - Work factor domains and their characteristics in the fabrication environment
    - Musculoskeletal disorder pain in the welders body region.
- To test and identify the personal attributes and employment factors for their influence on pain frequencies caused due to non reported highly frequent less severe work injuries among the welders.

- To compare mean pain frequencies caused due to non reported highly frequent less severe work injuries between the welder population and welders employed by firms in different sectors
- To compare mean pain frequencies caused due to non reported highly frequent less severe work injuries between welders employed by organised and unorganised sectors firms located in the engineering fabrication cluster.
- To determine the work factor domains that influence pain frequencies caused due to non reported highly frequent less severe work injuries among welders employed by firms in different sectors in the engineering fabrication cluster
- To identify influential personal attributes and employment factors that influence musculoskeletal disorder pain that causes annual disability in welders body regions, which in turn influence presenteeism phenomenon.

## 1.6 SCOPE OF THE WORK

The extent of the present research is:

1. The study relates to manual metal arc welders employed in BHEL ancillary Industrial Estates in Tiruchirappalli, Tamil Nadu State, India.
2. The study is the result of the questionnaire survey carried out in BHEL ancillary Industrial units supplying low technology fabricated components to BHEL.

## 1.7 THE RESEARCH FRAMEWORK

To investigate the influential factors that cause pain due to NRHFLS work injuries among welders employed by cluster of firms located in Industrial estates (referred as Engineering Fabrication Cluster) supplying low technology fabricated component to BHEL Tiruchirappalli, India. The broad methodology to achieve the objectives is shown in Figure 1.1. For the purpose, of the study, field visits to fabrication industries, consultation with experts,

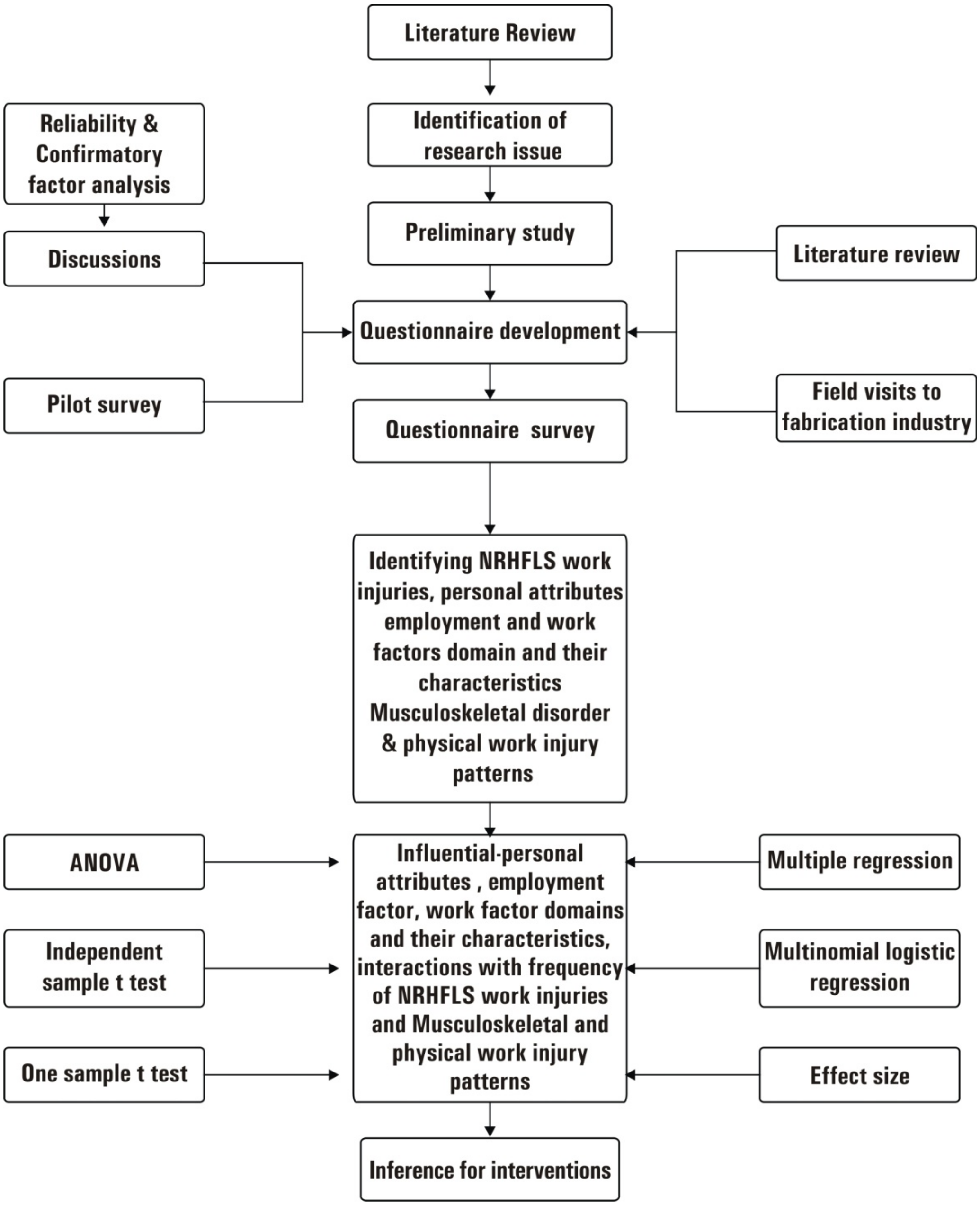



**Figure 1.1** The framework of research work

safety professionals, supervisors and welders were performed. Statistical methods were employed for the analysis of data thus collected. The results indicated significant areas where interventions efforts are required to focus on mitigating work injuries among welders in the engineering fabrication cluster.

## 1.8 ORGANIZATION OF THE THESIS

The thesis contains seven chapters. The contents of each chapter are presented below in brief.

**Chapter 1: Introduction**

This chapter discusses the accident, work injury and its specificity with welders. The theme of the thesis discusses the need and importance of work injury studies and its importance in Indian context and research issues of the study. The objective, scope of the study and research methodology adopted to accomplish the stated goals are described. This chapter finally summarizes the various chapters presented in this thesis.

**Chapter 2: Literature review**

This chapter discusses the accident and work injury literature by classifying them into five categories based on energy interaction sequence between the factors responsible for transformation of injury risk into injury incident and identifies the gap between them. This also briefs on the literature related to welder work injuries and presenteeism phenomenon. This chapter concludes with summary of observation from literature and the motivation with which the current research work is undertaken.

**Chapter 3: Research methodology**

The chapter describes characteristics of welder trade and description of the firms in the study cluster. The formation of survey instrument for the study is elaborated with its empirical validation. This chapter also describes how the data was collected and prepared for analysis and discusses the relationship between various factors in the study.

**Chapter 4: Influence of personal attributes and employment factors on pain frequencies due to non reported highly frequent less severe work injuries among welders**

This chapter compares the data by means of descriptive analysis of the welder population and welders employed by organised and unorganised sector fabrication firms. Personal attributes and employment factors were tested by parametric test like ANOVA, independent sample‘t’ test, one sample ‘t’ test for their influence on pain frequencies due to non reported highly frequent less severe work injuries. The ANOVA test revealed that personal attribute ‘age’ significantly influence pain frequencies. The independent sample t test revealed that employment factors: working hours, shift work, nature of employment, mode of apprenticeship training and physical workload significantly influence pain frequencies caused due to NRHFLS work injuries in the welder population that can be considered for intervention initiatives. This chapter also compares pain frequencies caused due to non reported highly frequent less severe work injuries among the welder population and welders employed by firms in various sectors.

**Chapter 5: Modeling the influence of work factor domains on pain frequencies due to non reported highly frequent less severe work injuries among welders**

This chapter elaborates the stepwise multiple regression analysis carried out to find out the influence of work factor domains (health perception, safety culture, physical task, mental task, physical environment, social environment, technical environment and perceived benefit) on pain frequencies caused due to non reported highly frequent less severe work injuries among the welder population and welders employed by organised and unorganised sector fabrication firms. The results showed that mean scores of work factor domains;

health perception, safety culture and social environment commonly influence pain frequencies due to NRHFLS work injuries in three groups, and can be considered for intervention initiatives.

**Chapter 6: Modeling the influence of personal attributes and employment factors on musculoskeletal disorder pain among welders**

Binary logistic regression was conducted to assess whether the personal attributes (age, experience) and employment factors (working hours, shift work, nature of employment, mode of apprenticeship training and physical workload) influence musculoskeletal disorder pain in welders' body regions. The analysis was carried out for weekly prevalence, annual prevalence and annual disability.

The result revealed shift work significantly influence musculoskeletal disorder pain in welder's body region for weekly and annual prevalence. Shift work also influence musculoskeletal disorder pain that causes annual disability (preventing normal activities) in welders (neck, shoulder, upper back and lower back) regions. Physical workload influence musculoskeletal disorder pain that causes annual disability (preventing normal activities) in wrist/hand and lower back regions of welder. It is also found that working hours influence musculoskeletal disorder pain that causes annual disability in welders lower back region. The factors that influence musculoskeletal disorder pain causing annual disability (preventing normal activities) promotes presenteeism phenomenon (present for work with ill health) which in turn reduces the productive effort of the welder due to ill health.

**Chapter 7: Summary and conclusions**

This chapter gives the summary of thesis followed by the findings of the research work undertaken and the contributions of the present research work. The chapter also discusses the scope of future work.

The contributions of the thesis are as follows:

The contributions of the thesis are as follows:

a) Developed an instrument framework for measuring pain frequencies due to non reported highly frequent less severe work injuries among welder.

b) Identified the personal attribute and employment factors responsible for their influence on pain frequencies due to non reported highly frequent less severe work injuries among manual metal arc welders.

c) Identified the six work factor domains: health perception, safety culture, physical task content, physical environment, social environment and perceived benefit that influence pain frequencies due to non reported highly frequent less severe work injuries in engineering fabrication cluster.

d) Identified the employment factors (shift work, working hours and physical workload) responsible for causing musculoskeletal disorder pain in the body regions of welders. These factors are responsible for causing detrimental effect by reducing the productive human effort among welders employed in engineering fabrication cluster.

e) Identified the factors that can be used for intervention efforts to mitigate the pain frequencies due to non reported highly frequent less severe work injuries among welders.

*Chapter* **2**

# LITERATURE REVIEW

Contents



## 2.1 INTRODUCTION

This chapter provides a comprehensive review of literature related to the work injury and accident research with emphasis on welder work injuries and presenteeism. The intent of this literature review is four-fold. First, to identify the gap in work injury and accident literature. Second, to examine and understand the gaps in welder work injury literature. Third, to provide an overview of literature related to presenteeism. Fourth, to align the observation from accident and work injury literature in tune with welder work injuries thereby providing motivation for the current research work. The following sections explain the aim of this literature review:

1. The literature on work injury and accident research
2. The literature on welder work injuries
3. Overview of literature on presenteeism concepts.
4. Observation from literature and motivation for current research

## 2.2 LITERATURE ON WORK INJURY AND ACCIDENT RESEARCH

A large and diverse literature is available on industrial safety, accident and work injury research. The available literature is drawn from different disciplines like – ergonomics, human factors engineering, industrial psychology, medicine, law and environmental sciences etc. In work injury research and accident causation theories, many areas overlap and have commonalities and confounding relationship between them. Published literature related to safety and work injury research suggests a consensus for delineating work injury research from accident research (Mckenna, 1983; Roberston, 1998).

### 2.2.1 Work injuries

Injury is defined as wound or trauma; harm or hurt or damage inflicted on the body of the injured by an external force (Webster, 2002). The injury is a (suspected) bodily lesion resulting from acute over exposure to energy interacting with the body in amounts or rates that exceed the threshold of physiological tolerance (ICECI, 2004). Energy exposures cause work injuries, which can be divided into two types namely (i) acute or short duration exposure called as traumatic injuries and (ii) chronic or long time exposure called as cumulative traumatic injuries. Further, these injuries can be classified as (i) intentional injuries for example, homicide and (ii) unintentional injuries that happens at workplace are called work injuries (Putz-Anderson, 1988; Tayyari and Smith, 1997). Terms 'accidents' and 'injuries' are closely related which are used synonymously though not synonymous (Hale and Hale, 1972; Langley, 1988). All accidents in the work place need not necessarily end up with a work injury, but every work injury is a result of an incident called as an accident. As per injury definition, energy transfer has to be above the physiological threshold, an essential prerequisite for an injury where there is no such qualifier for the accident. Injuries are hardly governed by chance while an event occurring through accident connotes a chance phenomenon (Wehmeier et al., 2005). Review of literature reveals that studies pioneered to investigate accidents in fact ends up in analyzing injuries (Langley, 1988).

## 2.3 TAXONOMY OF WORK INJURY LITERATURE

Work injuries are due to interacting sequences that occur in a work place. The presence of a hazard is a primary condition for work injury event to occur in a workplace. Causal factors in the work environment are responsible for the transformation of work injury risk into work injury incident. Energy interactions during work injury event influence how energy transfers to the victims body and defines injury severity. Based on energy sequence, the accident and work injury literature can be classified into five categories namely (i) hazard identification (ii) risk assessment (iii) accident and injury causation theories (iv) injury mechanism models and (v) injury intervention methods (Khanzode et al., 2012). The following sections summarizes the five categories of work injury and accident literature.

### 2.3.1 Hazard identification approaches

Workplace hazard is defined as event or situation with the potential for harm. A work place contains hazards in one form or another that contributes to an accident leading to human, economic, environment and general loss (Cox and Cox, 1993). For assessing work injury risk identifying the hazard is the first step, that involves recognizing presence of energy (e.g., rotating machinery, high temperature energy interactions etc) and process potentials (e.g., mechanical shocks, rapid pressure changes etc). Popular approaches employed for identifying hazards found in published literature can be classified into two types: formal and informal approach (Kumamoto and Henley, 1996). The formal approach employs specific hazard identification techniques while the informal approach uses historical data for evaluating the technical details.

Further these approaches can be categorized into three types namely biased reactive approach, biased proactive approach and unbiased proactive approach (Sukos, 1988; Wilquist and Torner, 2003).

Biased reactive is an informal hazard identification approach that analyzes information after the accident has occurred. All the general engineering evaluation belongs to this category.

Biased proactive approach is a formal approach that uses information of the similar work system or historic data of the same system. The examples of biased proactive approaches are forward tracking example Event Tree Analysis (ETA) and backward tracking methods example Fault Tree Analysis (FTA) (Lees, 1980; Harms, 1993; Kumamoto and Henley, 1996; Bahr, 1997).

Apart from ETA and FTA other methods that adopt biased proactive approaches are Cause Sequence Analysis (CSA) (Lees, 1980; Henley and Kumamoto, 1981; Kumamoto and Henley, 1996), Failure Mode Effect Analysis (FMEA) (Harms , 1993; Kumamoto and Henley, 1996; Bahr, 1997; Franceschini and Galetto, 2001) and Failure Mode Effect and Criticality Analysis (FMECA) (Kumamoto and Henley, 1996).

Unbiased proactive approach is a formal approach that carries out hazard analysis without waiting for events to occur and without any assumptions on hazards in the work system. All morphological methods falls under this category. These methods concentrate on potentially hazardous elements, for example energy concentrations, hazardous material and potential targets for example equipment and persons. This approach identifies the critical factors path leading to incidents that causes accidents.

The methods that follow morphological methods are change analysis (Ferry, 1988); deviation analysis, hazards and operability analysis, job and work safety analysis (Harms, 1993; comparison analysis (Kjellen, 1995); management oversight and risk tree (Johnson, 1980), and operation support and hazard analysis (Bahr, 1997). Hazards are specific to the work environment that requires domain specific knowledge and professional expertise to identify hazards (Maiti, 2005).

### 2.3.2 Risk assessment

The concept of risk quantifies the degree of harm which has likelihood and severity in response to workplace hazards (Cox and Cox, 1992). Risk is defined as expected damage or loss associated with the occurrence of a probable undesired event. Moreover, assessing risk involves recognizing potential threats and estimating their likelihood with severity (Kumamoto and Henley, 1996). A work injury risk is likelihood of being injured while doing a specific job. Assessing work injury risk involves identifying hazard, evaluating the risk and scheduling hazards based on the risk index (Maiti, 2005).

For estimating work injury risk, quantitative and qualitative methods are employed (Tixier et al., 2002; Arunraj and Maiti, 2007). Further, these two methods are classified into three types of approaches namely deterministic, probabilistic and combinatorial. Risk assessment process estimates the risk through classification, which solely depends on criterion variable and modeling techniques.

Quantitative risk assessment is suitable when injury risk is high and depends on the availability of relevant data, frequency and its severity expressed in quantitative terms and where detailed analysis justifies the cost. The outcome is represented in the form of risk profile. Qualitative assessment type of assessment is more viable for low risk events containing a small number of categories that covers a broad range of consequences and their likelihood. The outcome is represented with the aid of risk matrices where occurrence probability and severity forms the two axes. Risk assessment process involves two decisions (i) selection of criterion variable (ii) selection of a modeling technique.

The criterion variable is selected based on their suitability and type of risk assessment processes envisaged in a study. The more commonly used risk measure is injury rate, which is based on descriptive statistics (Pines et al., 1987; Jeong, 1999). Some of the studies have used criterion variable indices like lost time due to injury, injury frequency, fatal accident rates, cumulative incidence rate, severity rate, severity index, disabling frequency rate and disabling severity rate to quantify risk (Kjellen and Sklet, 1995; Boyd and Radson, 1999; Sheu et al., 2000). These measures are calculated based incidences during a period of time such as a month or year (Kjellen and Sklet, 1995; Duzgun and Einstein, 2004). The time between incident occurrences is also used as criterion variable indices in some studies (Maiti and Khanzode, 2009; Maiti et al., 2001).

Risk assessment process based on modeling techniques uses an ordinal scale for evaluating consequences of an accident/injury incidents (Kejriwal, 2002). Hazard identification techniques such as FMEA, FMECA, abbreviated injury scale and injury severity scale employ different kinds of classification schemes to weigh the consequences (Mitchell et al., 1993). Two way priority matrix for risk assessment is based on the probability of occurrence and severity consequences (Rao Tummala and Leung, 1996). Index of harm is a useful tool to compare occupational risk across various industries (Soloman and Alesch, 1989). Accident/injury risk is also modeled through appropriate statistical distributions by fitting the distribution of occurrence probability or the consequences (Boyd and Radson, 1999; Cuny and Lejeune, 2003; Chang, 2004; Maiti and Khanzode, 2009; Maiti et al., 2001; Khanzode et al., 2011). Beta distribution based model employ lost workdays for example, in a consequence model lost workdays is an indicator of injury risk (Coleman and Kerkering, 2007). Acute traumatic injuries occurring to individuals follows a poisson process and the inter injury periods are exponentially distributed (Boyd and Radson, 1999). Injuries modeled using mixed Weibull distribution considers them as failures, which is analogus to reliability principles. Such models assume differential injury liability across individuals. Poisson regression models (Bailer et al., 1997) are used for adjustment of injury rates for one or more explanatory variables for example, age, experience and occupation. In conditional probability based models risk of injury is captured through three phased mechanism namely, pre-injury, injury and post-injury phases (Kjellen, 1984b,c). Some studies indicate artificial network based models are being used for evaluating an injury risk and to classify accordingly (Zurada et al., 1997). A study indicates development of functional block diagram model for quantification of occupational risk (Papazoglou and Ale, 2007). Apart from injury risk assessment methods, various other techniques found in literature to measure injury risk among industrial workers are Rapid Upper Limb Assessment (RULA), postural Loading on the Upper Body Assessment (LUBA) and Quick Exposure Checklist (QEC) (Kee and Karwowski, 2001, David et al. 2008, McAtamney and Corlett, 1993). The risk of human errors in a working system is evaluated by using techniques like Action Error Analysis (AEA) and Cause Consequence Analysis (CCA), Success Likelihood Index Method (SLIM) and Human Error Probability Index (HEPI) (Khan et al., 2006, Kirwan, 1990, Reason, 1990, Singleton, 1984a). Probabilistic Risk Assessment (PRA) is widely used methodology for reliability and risk assessment in chemical, aerospace, nuclear and other high risk industries (Kumamoto and Henley, 1996).

### 2.3.3 Accident causation theories

Over years, the researchers have postulated many causation theories. These theories can be divided into four generations (Khanzode at al., 2012). The classification of first generation theories relate primitive viewpoint towards accident causation, which holds that persons trait and unsafe behaviour are responsible for the accident (Greenwood and Woods, 1919). The second generation referred as domino theories account for a chain of sequential events that leads to an accident, and the events were named as dominos (Heinrich, 1932). Removing any one of the dominos would halt the chain of accident events. Domino theories are employed for accident mitigation among industrial workers (Heinrich et al., 1980).

**Table 2.1: Accident theory generations**

| Generation | Theories | Features |
|---|---|---|
| Generation I | Accident proneness theory | Personality traits responsible for accident, Differential involvement in accident, Behavioural interventions |
| Generation II | Domino theories | Unsafe act and condition as immediate predecessors of accident, Intervention focused on unsafe acts |
| Generation III | Injury epidemiological theory | Uncontrolled energy transfer focused, control at pre-injury, injury and post-injury stages |
| | System theories | Holistic approach integrated safety systems |
| Generation IV | Socio-technical system theory | Interacting social and technical subsystems job design based on STS principle |
| | Macro-ergonomics systems | Holistic approach like system models, Organisation centered approach |

A variation of domino theory was proposed by Kjellen (1984 a, b) called as deviation theory that identifies possible deviation separately and then evaluates quantitatively. Injury epidemiological models represent third generation theory, which views that accident prevention efforts do not necessarily lead to injury control in the work system. This approach primarily focuses on the energy transfer involved in injury incident and attempts to minimizes loss. The fourth generation theories emerged in 1970s as a response to maintain safety in increasingly complex work system. An example of such approach is socio-technical systems and macro-ergonomic approaches (Trist and Bamforth, 1951; Hendrick, 1986). The Table 2.1 summarizes the four generation accident theories.

There is an association among the four generation accident theories, accident causation themes and causal factors of work injuries. The premises of accident causation relate person, system and system person sequence as the causes (Paul and Maiti, 2008). Each premise examines specific causal factors to explain accident and work injury events. Causal factors responsible for the accident and work injury event can be individual related, job related and organization related (Paul and Maiti, 2007, 2008; Bajpayee et al., 2004). Premises between the generations of accident theories and their causation themes are shown in Table 2.2.

**Table 2.2: Premises between generation and causation theme**

| Generation | Causation theme | Type of factors examined |
|---|---|---|
| Generation I | Person as cause (unsafe act) | Individual related |
| Generation II | System as cause (unsafe conditions), Person as cause (unsafe acts), | Individual and job related |
| Generation III | System person sequence (energy interactions) | Job related leading to interactions |
| Generation IV | System as cause, person system sequence | Organization related, job related and individual related |

The above three factors have been highlighted by researchers in the past three decades. These factors and their representative studies affecting work injuries are exhibited in the following sections.

#### *2.3.3.1 Individual related factors affecting work injury*

| No | Individual related factors | Representative studies |
|---|---|---|
| 1 | Age increases injury risk | Fotta and Bockosh, 2000, Jeong, 1999 |
| 2 | Age is not associated with work injury risk | Bennett and Passmore, 1984a |
| 3 | Less experience correlates with high work injury risk | Keyserling, 1983, Buttani, 1988 |
| 4 | Young worker less than 25 years age are prone to higher injury risk of non-fatal injury and while older workers are prone to high risk of fatal injuries incidents | Salminen, 2004 |
| 5 | Absence of correlation between age, experience and work injury | Gun and Ryan, 1994 |
| 6 | Age, experience, education correlate well with work injury and poor performance | Leigh et al., 1990 |

### *2.3.3.2 Job related factors affecting work injury*

| No. | Job related factors | Representative studies |
|---|---|---|
| 1 | Injury risk differs job wise and number job related factors are predictors of injury risk | Ferguson et al., 1985 |
| 2 | Relationship between injury and organization related factor is stronger than individual related factor | McLeod et al., 2003 |
| 3 | Occupation is significant with work injury | Leigh et al., 1990; Maiti et al., 2001 |
| 4 | Work location is significant with work injury | Leigh et al., 1990; Maiti et al., 2001 |
| 5 | Work system hazards are significant with work injury | Khanzode et al., 2011 |
| 6 | Work factors are significant with work injury | Haslam et al., 2005 |
| 7 | More probability of getting injured while performing a certain hazardous job – manual material handling | Davies et al., 2003 |
| 8 | Shift working is significant with work injury | Levin et al., 1985, Frank, 2000 |
| 9 | Job stress causes work injuries | Paul and Maiti, 2005 |
| 10 | Job dissatisfaction associated with injury risk | Paul and Maiti, 2005 |
| 11 | Job responsibility associated with injury risk | Ferguson et al., 1984,1985 |
| 12 | Work performance associated with injury risk | Ferguson et al., 1984,1985 |
| 13 | Effect of technology, reduces risk in one area and increase in another area | Blank et al., 1996 |
| 14 | Mechanization reduces injury numbers | Sari et al., 2004 |

### 2.3.3.3 Organization related factors affecting work injury

| No. | Job related factors | Representative studies |
|---|---|---|
| 1 | Organization factors are important causal factors in accident incidents | Powell et al., 1971 |
| 2 | Safety climate – molar perceptions that employees share about their work environment | Zohar, 1980 |
| 3 | Work group size are related to low injury incidents >15 workers | Guastello and Guastello 1987; Maiti et al., 2004, |
| 4 | Support from management reduces injury risk | Gillen et al., 2002 |
| 5 | Coworker support and supervisory support reduced injury risk | Gillen et al., 2002; Maiti et al., 2004 |
| 6 | Management commitment to safety associated with injury risk | O' Toole, 2002 |
| 7 | Workplace safety status associated with injury risk | Lindell, 1997; Gillen et al, 2002 |
| 8 | Worker's who perceive work environment as safe, perceive management and coworker support as high in turn low injury incidents | Gillen et al., 2002 |
| 9 | Unsafe behavior correlates with high work injury risk | Andriessen, 1978; Prussia et al., 2003 |
| 10 | Role over load is associated with injury | Mullen, 2004 |
| 11 | Organization's priority to performance over safety reduces work injury risk | Mullen, 2004 |
| 12 | Socialization at work is associated with work injury | |
| 13 | Poor safety attitudes (Rundmo and Hale, 2003; Mullen, 2004), | Mullen, 2004 |
| 14 | Perceived hazards is associated with injury risk | Seo, 2005 |
| 15 | High perceived risk are associated with low injury rate | Rundmo, 1996; Mullen, 2004,; Seo, 2005 |
| 16 | Low injury rate with tightly coupled systems | Perrow, 1984 |

| | | |
|---|---|---|
| 17 | Fair perception in safety climate leads to shared understanding of unsafe behavior | Prussia et al., 2003 |
| 18 | Safety climate and safety performance increases attention towards injury risk | Vinodkumar and Bhasi, 2009 |
| 19 | Instruments measuring safety climate predict injury rates with varying strength and validity. | Siu et al., 2004 |
| 20 | Safety attitude and psychological distress affect injury rates | Siu et al., 2004 |
| 21 | Negative affectivity affects safety climate and performance, affects injury rate | Maiti et al., 2004 |
| 22 | Poor safety environment is a factor to injury | Paul and Maiti, 2008 |
| 23 | Industry specific hazards affect the relationship between safety climate and safety performance with increased injury rate | Smith et al., 2006 |

### 2.3.4 Injury mechanism models

Energy transfer to human body is the key issue in an injury incident. Work injury models explain how energy is built into a working system and points out the underlying cause that releases the uncontrolled energy. The presence of a human in vicinity of uncontrolled energy release is necessary for modeling work injury. Many factors come into play in an industrial setting, and consideration of energy interactions that occurs at the time of injury incidents is important. The entire chain of injury mechanism is not simple, linear rather multi-phased, complex and unpredictable (Perrow, 1984). Till 1960s objects that carried energy were considered as injury agents. Later mechanical, thermal, chemical, electrical energy and ionizing radiation are considered as agents of injury (Robertson, 1998). A matrix proposed by Haddon (1972) classified injury related event in three phases as pre-injury, injury and post-injury for the host, vehicle and environment. Later the researchers used this classification to arrive at a multi-phased structure of injury mechanism.

Since then, different investigators have examined multiple phased structure of injury mechanism. The models that explain injury mechanism in an injury event can be classified into two groups namely deviation models and energy models. The following sections explains the injury mechanism models:

#### *2.3.4.1 Deviation models*

The deviation models consider the deviation in system characteristic that attains a value which exceeds the prescribed norms (Kjellen, 1984a; Kjellen and Hovden, 1993). Injury incident is classified into three namely initial phase, concluding phase and injury phase (Kjellen and Larsson, 1981). Also, injury mechanism is perceived in the form of three tiers considered as originating influences, shaping factors and immediate accident circumstances (Haslam et al., 2005). Deviation models account injury due to deviation in the system variables that lead to the release of uncontrolled energy (Kjellen, 1984b,c). Further, development and reporting of this model are scarce.

#### *2.3.4.2 Energy models*

Energy models consider energy in different phases of injury mechanism. Energy builds up in a work system and human interactions with system energy plays a significant role in injury incident (Tuominen and Saari, 1982). These stages are divided into three namely: energy build-up phase, energy release phase and impact phase (Haddon, 1964). Investigation of uncontrolled energy transfer as a direct cause of injury is the initial step in injury analysis (Storbakken, 2002).

### 2.3.5 Injury severity models

Injury severity in a work system can be minimized by analyzing the factors that cause the severity of the impact based on lost man days in a given situation. Factors influencing injury severity are not the same as the factors causing injury. Contrasting literature exists for injury severity. Identical causation hypothesis perceives major fatal injuries are caused by different factors when compared to minor and nonfatal injuries that lack explaining injury severity (Heinrich et al., 1980; Lozada et al., 1987). However differential causation hypothesis differentiates injuries of varying severity and attempts to analyze injuries in light of varying severity (Hale and Hale, 1972; Petersen, 1989; Salminen et. al., 1992). Validation of differential hypothesis has been carried out in certain industries like mining industry and independent occupations in Swedish industry ((Petersen, 1989, Salminen et al., 1992). A review by Shannon and Manning (1980) reveals injury severity depends on the energy interactions that are involved in an injury event than a chance factor. Other factors that influence varying injury severity are age, experience, job, location and physical workload (Bennett and Passmore, 1984b, 1985).

**Discussion:** An injury incident follows a chain of events starting with the presence of a hazard and leading to injuries of varying severity. The observation from the literature reveals several methodological gaps.

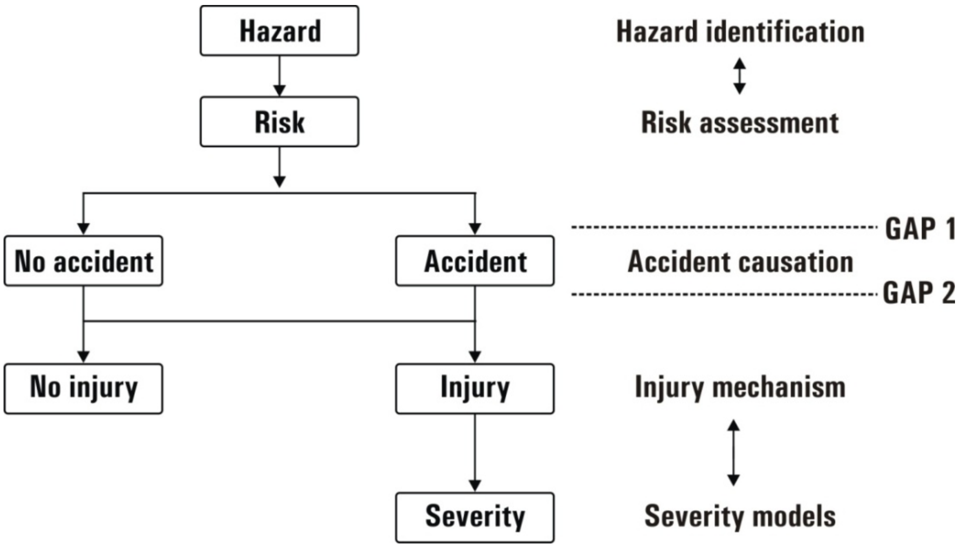



**Figure 2.1** Gaps in accident and work injury literature

Hazard identification and risk assessment methodologies are well interfaced, for example, ETA, FTA, FMEA and FMECA. However, accident causation models are not interfaced with hazard identification and risk assessment methodologies. Understanding 'gap 1' helps to assess whether the accident would occur in a stated condition. On the hand, injury mechanism model and injury severity model are well interfaced but not with accident causation model. Analyzing 'gap 2' helps to understand how risk is transferred to an accident event first and then to an injury event. According to fourth generation accident causation theories, interactions between three factors: individual, job and organizational are responsible for an injury event

Causation models for a complex level accident are well suited for analyzing event chains that lead from component level to system level failures and eventually to an accident. These complex event chains lead to less frequent highly severe work injury incidents. However given the injury research, highly frequent less severe work injury incidents are important in light of manufacturing sector (Khanzode et al., 2012). Methodologies available for analyzing the less frequent and highly severe work injury incidents are not suitable for analyzing the highly frequent less severe work injury incidents and do not reveal about work injury patterns. Higher numerical indicators in work injury databases reflect the ineffectiveness of these methodologies. Moreover, injury risk profiles across different jobs and work systems are not available nor reported in published literature (Khanzode et al., 2012). Further, hazard identification and risk assessment techniques are widely employed for assessing chemical, process-related hazards and accident risks than mechanical industries and traumatic work injury risks. Based on the above facts, it is highly important to address highly frequent less severe work injury risks specifically to an industrial setting.

## 2.4 LITERATURE ON WELDER WORK INJURIES

An analysis on south Indian coastal fabrication industry in a sample of 209 welders in metal fabrication industry by Ganesh and Priya (2014) in a study period of one year reports that all the welders experienced a minimum of two injury exposures, and 44% had more than ten injury exposures. The common injury patterns found among welders were abrasions lacerations, foreign body in the eye, flash burns, cut injuries and contusions. A study by Adelani et al. (2014) on the usage of safety device by welders in Nigeria, concludes that more the knowledge of welders in the art of welding better the use of safety device. The study also reported a significant difference between the welders educational qualifications, experience and the use of safety devices. A study by Anuradha et al. (2014) on welders occupational health, found positive association between exposure duration and various hazards in fabrication sector. A survey on 100 welders employed in local workshops and an industrial center in Palakkad revealed health complaints related to arc eye injuries (>90%), followed by burns (88%), skin problems (69%), tiredness, sleepiness and muscular weakness (45%), hearing impairment (35%) and respiratory ailments (22%) (Biji et al., 2013).

A review by Clarice et al. (2013) on apprenticeship welder and preventive medicine concluded with concern for respiratory health, genetics, neuro psychology and suggested for improvement in welding techniques. It also stressed the need for knowledge construction during apprenticeship before the placement of trained welder in the labor market. He suggested for assistance in work injury and public health area specific to the welder health. A study related to risk perception and occupational accidents among apprenticeship welders by Marta (2012) reported that apprentice welders realize injury risk when they expose themselves to risk factors. The report revealed that frequency of injury incidences during apprenticeship training reinforces the perception of injury risk factors among apprenticeship welders.

A comparative survey on the prevalence of work related musculoskeletal disorder and risk factors by Ebrahimi (2011) among Iranian welders concluded that 88.3% welders suffered from some or other forms of musculoskeletal disorder symptoms. The more prominent musculoskeletal disorder symptoms associated with welder work were found to be prevalent in neck, wrist and hands. The results of the survey revealed that employment duration of welder as a factor was responsible for Work Related Musculoskeletal Disorder (WRMSD) in shoulder, lower back, neck, and knee regions. These findings suggests for vigilant appropriate intervention in welding workplace. A survey on eye injuries by Adelani at al. (2014) among 110 welders in Nigeria, reported flying metal chips as the chief source for eye injury experienced by welders. Out of the total study sample 68.15% of the welders had history of work related eye injury. The other source in their work environment that influenced the eye injuries was arc rays which accounted for the 31.85% of the total sample. The study also highlighted the high level of awareness among welders for eye injury risk from the welding process. The study further reported that only 15.3% of the welders were using protective eyewear at the time of an injury. Moreover, he suggested that using safety intervention programs like awareness campaign, programs by relevant government agencies, encouragement of locally produced eye protectors and involvement of medical practitioners as solutions in preventing ocular injury among welders.

Findings related to radiation from arc welding published by CCOHS (2011) specifies a broad range of wavelength from (200 - 1400 nm) from the welding arc that include ultraviolet radiation (200 - 1400 nm), visible light (400 - 700 nm) and infrared radiation (700 - 1400 nm). Out of these, certain types of radiation cause injury to mucous membrane commonly referred as arc eye, welders eye, or arc flash. Photo keratitis or arc eye occurs due to a bright ultraviolet light from the high temperature arc that causes inflammation in the cornea. On certain occasions due to prolonged exposure to ultraviolet rays retina in the eyes is charred or may lead to the medical condition termed as cataracts. Further, the visible light produced during arching process interferes with iris mechanism in the eye that regulates light reaching retina leading to temporary blindness and fatigue. A study on vibrations produced during the arcing process in the arc welding machine by Sobaszek et al. (2010) revealed vibrations leads to soft tissue damage that causes uneven blood flow in the capillary veins in hand that leads to Hand Arm Vibration Syndrome (HAVS) or Reynold's Syndrome, for example, blanching of fingers or white fingers. A study by Sabitu et al. (2009) on awareness of occupational hazards and utilization of safety devices among the 330 welder in a non industrial setting revealed that awareness of arc welding hazards were high (83%) in the sample and it was influenced positively by age, educational status, marital status, work experience, type of training and supervision. The study also reported that use of protective gear was minimal among welders. Further, the study reported that hazard perception about welding trade was high among Nigerian welders when compared to Indian welders, where only few welders perceived their welding trade as hazardous. The study suggested for health and safety education for improving safety awareness among welders. A review of literature on hazards associated with arc welding process highlights the trauma of physical injury experienced by welders. The type of physical injury experienced by manual arc welders are physical damage or injury including exposures to excesses heat, noise, vibration, electrocution, ionizing radiations and physical trauma (Erdal and Berman, 2008). Arc welding produces noise level more than 120 dB during the arching process. Any noise level more than 90 dB is likely to damage the human hearing sense due to damages in sensory hair cells of the cochlear that results in conditions like permanent deafness, fatigue, and nervousness leading to a noise-induced hearing loss (Twin et al., 2008). An analysis on noxious fumes and blue light effect on welders during an arc welding process reveals carbon dioxide gas and ozone affects the welder respiratory system due to the inadequate ventilation system particularly in confined spaces, which has a bearing on fatal injury conditions. Blue light causes temporary or permanent scarring of the retina, which causes blue light insensitiveness in eye that result in blindness. Long terms exposure to radiation have a greater probability of mutating malignant changes, genetic changes, damage and blood disorders like leukemia, dermatitis, and sterility (Blunt and Balchin, 2005). Inhalation of dangerous gases that include particulate matter have been reported among welders working on joining different metals (Prabhakara, 2002). This condition leads to inhalation of iron dust that causes respiratory changes, chromium dust causes skin lesions, perforation of the nasal septum and toxicity leading to a severe medical condition known as metal fume fever. Lack of adequate and confined space in the work bay or site for welding is stated as the prime reason for higher likelihood of an injury risk and decreased welder productivity (Stern et al., 1986).

A meta analysis of epidemiologic studies on welders reports the link for the presence of confounding factors like presence of asbestos in the welding environment to be similar to that of tobacco smokers habit (Moulin et al., 1997). A study on welding works bay design recommends improved tools based on the ergonomic research and work shifts as the efficient method for an on-the-site activity where welder has to adapt the posture for weld task (Khadefors et al., 1997). A research finding on Rawalpindi roadside arc welders in Pakistan concluded for a call on effective public policy on preventive education and effective safety regulation in informal welding sector (Shaikh and Bhojani, 1991). A survey conducted on manual metal arc welders' occupational health revealed variety of health and safety hazards. The results suggested for an ergonomic knowledge based interventions with emphasis on selecting right process parameters and consumables (Hewitt, 1996). Quantitative electromyography analysis on shipyard welders revealed that elderly welders who experienced shoulder pain had similar muscular fatigue profile to that of an experienced welder. The study also found that muscle fatigue was higher for shipyard welders who had worked using their arms elevated position (Kadefors et al., 1976).

**Discussion:** Examining the available literature, most of the studies relates to cumulative trauma disorders based on morphological methods. Majority of the welders related work injury studies were analysed in epidemiological viewpoint. Few studies address the prevalence of musculoskeletal disorder and physical work injuries among welders employed in non industrial setting. Some of the injury studies consider welding process parameters, postures adopted by the welder during the weldment process, method through which welder trade knowledge was acquired as factors that influence work injury experience among welders. A gap exist to explore the influence of personal attributes, job related and organizational factors influencing pain frequencies due to non reported highly frequent less severe work injuries among welders employed in industrial fabrication environment.

## 2.5 OVERVIEW OF LITERATURE ON PRESENTEEISM CONCEPTS

Productivity is a measure, which indicates the economic, social health and describes the existence of business opportunities in a society. The traditional way of thinking productivity is synonymous with input (e.g., number of hours worked) and output (e.g., some units produced) generally discussed in economic perspective. This discussion often neglects the workers health and its effect on his/her productive state. The state of workers health is thought in concern with the state of being away from work due to ill health or being present for work with ill health. Worker present for work with ill health inhibits the productive effort, this conceptualization has not gained popularity in injury research till recently. At present, workers ability to produce goods and deliver services while suffering from the work related musculoskeletal disorder and work related physical injuries has been an area of interest in work/occupational injury research. Regarding worker productivity, absenteeism is defined as the number of days missed by the worker due to ill health induced by work related issues. While, Presenteeism is defined as worker present for work with ill health (Burton et al., 1999; Boles et al., 2004). In developed countries absenteeism is a more common measure for evaluating productivity in particular with the countries having high insurance coverage (Askildsen et al., 2005). Examining the published literature, researchers have shown interest in analyzing the relation between absenteeism and poor workplace conditions (Kahya, 2007); peer behavior and absence cultures (Bamberger and Biron, 2007) and job satisfaction and involvement (Wegge et al., 2007).

Presenteeism is defined as workers turning up to the work despite ill health condition or bearable pain that should have prevented from attending the work (Aronsson et al., 2000). Presenteeism characteristic is time being not on task, reduced quality, quantity of work, poor relationship with co-workers and unsatisfactory work culture (Loeppke et al., 2003). Studies have shown a positive correlation between presenteeism and increased morbidity during work; this includes musculoskeletal disorder pain and physical work injuries (Grinyer and Singleton, 2000; McKevitt et al., 1997; Aronsson et al., 2000; Burton et al., 1999). A study on presenteeism among workers employed in USA reports 71% of the 226 billion dollars worth of lost productive time per year, 88% failure to meet productivity standards and 40% productive work lost per week (Stewart et al., 2003).

To quantify presenteeism, one has to rely on self reports where the respondents have to note when they have turned up when sick (Burton et al., 1999). Measuring impact of presenteeism on productivity is difficult as it is neither visible nor studied easily. Reviewing the literature shows presenteeism has a bigger drain on productivity due to work injury induced morbidity, than absenteeism (Hemp, 2004).

**Discussions:** There have been few research inputs on presenteeism as it is not visible or readily studied. The present study attempts to identify factors that influence presenteeism in form of factors and pain experienced by welders due to non reported highly frequent less severe work. The outcome of the study would point out the influential factor (personal attributes, employment and work factors) that influence pain frequencies. These influential factors are likely to induce presenteeism that affects the welders effective productive effort employed in the fabrication industry.

## 2.6 OBSERVATION FROM LITERATURE REVIEW AND MOTIVATION FOR CURRENT RESEARCH

### 2.6.1 Observation from literature review

Accident causation models are more suitable for analyzing complex event chains that lead from component level to system level failures and cause accidents. The complex chains lead to less frequent highly severe work injury incidences and not to highly frequent less severe work injuries. The models developed to identify these incidences that cause accidents are more suitable to assess chemical and process industry related hazards and accident risks, than to mechanical and manufacturing industries. As the nature of work and injury risks associated with them are different. In this perspective of injury research, these models are of limited use to identify work injury patterns to mitigate effectively. Moreover, timely availability of relevant, reliable and comprehensive data on work injury surveillance from different industrial sectors imposes the restriction on work injury research. However, in the area of injury research work injury incidents are important for manufacturing sector. Any work injury causes pain and any pain in the human body is a deviation from a healthy state of a worker irrespective of the variation in its severity. Hence, pain has a higher likelihood of causing morbidity that manifests in a form of reduced effective effort by the worker which is conceptualized as reason for presenteeism in this study. The study in its endeavor attempts to understand how factors like personal attributes, employment and work factors influence injury risk which is transferred to an accident and then to an injury incident in an industrial fabrication environment. Published literature reveal personal attributes, employment factors and work factors influence reported work injuries and studies related to the influence of these factors on non reported work injuries are scarce especially in welding trade/profession.

### 2.6.2 Motivation for current research

Manual arc welding is a high temperature process that carries inherent hazards that involve energy interactions with the welder who performs it. At frequent occasions, these energy interactions lead to energy exchange causing work injuries for example, an arc eye, musculoskeletal disorder pain due to incongruent prolonged posture that causes pain/morbidity etc to the welder employed in fabrication environment. These work injuries are generally treated with first aid and are not generally reported. The pain induced due to these work injuries is likely to reduce the effective productive effort during the work of a welder promoting presenteesim phenomenon.

Work injury and accident literature indicates personal attributes and employment factor are widely studied for their influence on work injuries among workers/welders. Further, published literature reveals energy interactions between different work factors in the work place leading to highly frequent less severe work injury incidents. Moreover, majority of the published studies are related to reported work injuries and studies on non reported work injuries among welders are scarce. The study in its endeavor attempts to find the influential personal attributes, employment and work factors that influence pain frequencies due to non reported highly frequent less severe work injuries and musculoskeletal disorders among industrial welders.

………ꕤ………

*Chapter* **3**

# RESEARCH METHODOLOGY

Contents



## 3.1 INTRODUCTION

The chapter briefs the

- Welder trade characteristics
- Description of the study cluster
- Design of the survey questionnaire
- Data preparation and analysis
- Discussion on relationship between various factors

## 3.2 DESCRIPTIVE CHARACTERISTICS OF WELDER TRADE

### 3.2.1 Description of welder

The International Standard Classification of Occupations (ISCO) defines welders and flame cutters as persons who performs welding and cutting metal parts using gas flame, electric arc and other sources of heat to melt and cut, or to melt and fuse metal. The work of a manual metal arc welder employed in industrial fabrication industry involves customizing fabrication configurations in structural steels, piping or repairing damaged or worn out parts. Manual metal arc welders find employment with industrial fabricators, mechanical contractors, platform manufacturers, and transportation contractors.

Welders are employed in physically demanding work conditions that present high injury risk to their professional practice (Herberts et al., 1976). Examples of parts fabricated by industrial welders are pressure vessels, structural works, heat exchangers and boiler components. The welder trade in developing countries involves wide range and varieties of activities that are irregular, invisible, non structured and these operations draw parallel with that of professionally trained welding professionals (Adelani et al., 2014). Sometimes the welder trade overlaps with sheet metal workers, steam fitters and metal fabricators (Occupational analysis of welders – 2009).

Technological advances in metal arc welding process have come up in the form of improved electrodes and wire feeders that have resulted in lighter welding equipment incorporating ergonomic principles. In some industrial fabrication areas, development methods like parallel line and radial line methods have moved from shop floor to design office. But, these facilities are not available for an average welder in developing countries. In spite of these technological developments, the fundamental welding process and work injury hazards remains the same irrespective of the geography.

### 3.2.2 Task of a welder

The tasks of a welder involve:

In addition to the primary task of welding, the associated task of a welder include -

i. Maintaining tools and equipment such as setting trade machinery, presses, oxy fuel cutting torches, shears, plasma cutters, grinders, drills, and bending, cutting and forming metal components.

ii. Organizing work for example, making of safe environment, document, drawings communication, compiling the material list and planning project task.

iii. Performing quality control for example, marking materials and parts, verifying layout, heat treating material and storing consumables.

iv. Performing routine activities for example, hazard assessment, starting up and shutting down power source equipment.

v. Handling materials for example, obtaining materials, verifying bill of material, organizing material, rigging, hoisting, and operating handling equipment.

vi. Performing layout for example, developing template, transferring dimension from drawing to materials etc.

Despite these main tasks, numerous sub tasks that require knowledge and ability by a welder are shown in Appendix Figure AF1 to AF6 (Occupational analysis of welders – 2009)

### 3.2.3 Welder work hazards and work injuries

Manual metal arc welding involves high energy interactions above 10000 K that results in hazards like fire/explosion, electrocution, physical trauma and respiratory disorders (Hewitt, 1996). Physical causes that influence work injuries are noise, vibration, radiation, ionizing laser rays, excess heat and physical trauma (Erdal and Berman, 2008). Some of the other serious damages to the welder include radiation injuries, blanching of fingers due to hand arm vibration and permanent hearing loss due to noise more than 90 dB (CCOHS, 2011; Sobaszek et al., 2010; Twin et al., 2008). A review on chronic effects of radiation and inhalation of welding fumes concludes blood related disorders and respiratory problems as the possible cause for morbidity among welders

(Prabhakara, 2002). Inadequate ventilation during weldment leads to respiratory morbidity due to direct inhalation of carbon dioxide (Blunt and Balchin, 2005). Welding and cutting process produce hazards like sparks, radiation, hot metal fumes, gas and electric shock that results in fatal injuries (Adelani et al., 2014). Prominent prevalence of Musculoskeletal Disorder (MSD) in the body regions of welders are found in the neck, shoulder, elbow, wrist, hands, upper back, lower back, thighs, knee and ankle (Ebrahimi et al., 2011). Common physical work injuries among welders include burn, cut injuries in hands and fingers, fracture, arc eye, hearing impairment, tremor, chest and breathing difficulty (HS04 – 044A, 2012). Further, these work injuries vary in their severity that can be classified into reported or non reported in nature.

## 3.3 DESCRIPTIONS OF THE STUDY CLUSTER

This study was carried out in the Engineering Fabrication Cluster (EFC) situated around Bharat Heavy Electricals Limited (BHEL) Tiruchirappalli. BHEL is the largest public sector engineering enterprise in India. To promote entrepreneurial talent, the company encourages its own people to take up the entrepreneurial venture. The company also supports them by passing off their low technology fabrication components and outsources the finished components. This patronage by the company has led to the development of ancillary units around the periphery of BHEL in the form of an EFC commonly referred as Industrial Estates. The EFC houses approximately 400 small and medium scale fabrication units, 100 machine shops and a good number of micro units engaged in shot blasting, drilling, galvanizing, bending, manufacturing of electrodes, grinding wheels and paints.

Regarding the activity in EFC, the main products fabricated are power equipment like boilers, heat exchangers, pressure vessels, windmills, and structures. The higher growth trajectory of BHEL in power sector promoted large scale outsourcing from these Small and Medium Scaled Enterprise

(SMEs) located in this EFC. In last five decades, the number of SMEs has grown from 26 to 400 firms, that employs 20000 workers where welders form the dominant work group, with almost no women in the workforce. The firms located in EFC directly employ around 20% of the work force while 80% of the work forces are employed through the man power contractors for contract/ adhoc employment (Appendix AF.17).

Liberalized Indian economy has witnessed many multinational companies outsourcing their products from this EFC. With the state government increasing the outlay for power production and promoting increased use of non conventional energy sources, new products like windmills and rice husk boilers have increased the turnover exponentially in this engineering fabrication cluster. Despite the higher growth rate, challenges emerge in the form of poor access to transport, poor power infrastructure in these industrial estates, unsafe working conditions and poor material handling in these industrial estates. Welding and gas cutting operations continue to be the leading cause of work injuries in this EFC (CSR perceptions and activities of small and medium enterprises in seven geographical clusters, UNDIO survey report, 2008).

### 3.4 DESIGN OF SURVEY QUESTIONNAIRE

The survey questionnaire is made of five sections: pain frequencies due to Non Reported Highly Frequent Less Severe (NRHFLS) work injuries, personal attributes, employment factors, work factor domain and their characteristic items and Modified Version Standardized Nordic Questionnaire (MVNQ) for measuring musculoskeletal disorder pain (See Questionnaire). In addition to the above question regarding the firms' registration status with Small Scale Industry Association (SSIA) and name of the respondent as optional response were included in the questionnaire. If the firm had the registration with SSIA, the firm was considered as an organized sector firm and otherwise it was considered as an unorganized sector firm. The five sections of the questionnaire are described in the following sections.

### 3.4.1 Pain frequencies due to non reported highly frequent less severe work injuries

Different indices are used in safety and work injury literature to measure work injuries (See sec 2.3.2). The present study considers self reported pain frequencies due to non reported highly frequent less severe Khanzode et al. (2012) work injuries among welders performing manual arc welding work as the criterion variable.

The meaning of highly frequent in this study refers to painful work injury frequencies that are very likely to happen in the period of event that has greater than 95% probability while less severe means 'negligible category, ' an injury pain treated with first aid (Nasibeh Azadeh Fard et al., 2015). Further, this type of work injuries are neither recorded nor reported even in developed countries (Anne and Ann, 2004. p.8). In Indian context, recording of this type of work injuries are scarce and recording of work injuries are not industry specific but listed under general medical conditions (Gururaj, 2008). In the absence of valid work injury surveillance estimates, self reported work injury survey provide means of data on pain, symptoms, perceived exertion, task specific tools or equipment that causes pain or discomfort (Wiktorin et al., 1993). Hence, self reported method of collecting information was selected for this study.

A welding work involves high temperature energy interactions during the course of weldment process that makes the welder susceptible to frequent painful work injury exposures such as first degree burn, cut injury, MSD pain etc., that are not at all reported. Any form of pain in the welder body region is a deviation from the healthy state of welder that leads to morbid state promoting presenteeism phenomenon (See sec 1.4) during weldment work. This morbid state is likely to interfere with welders effective productive effort. Review of work injury studies for selecting recall period (i.e. the length of time between the injury and the interview) reveals that for severe injuries a period of one year is too long and a period of three months is more appropriate (Warner et al., 2005; Harel et al., 1994; Mock et al., 1999). For less severe injuries, a shorter recall period of seven days to one month is more appropriate (Warner et al., 2005).

Based on above discussion, recall period of one month for self reported pain frequency due to NRHFLS work injury is envisaged for the study.

### 3.4.2 Personal attributes

#### *3.4.2.1 Age*

Age has been the most widely studied factor for their relationship with work injuries. Published literature on work injuries reveal contrasting evidences.

- Studies on coal mines reported no relationships between age and work injury (Maiti and Bhattacherjee, 1999; Breslin et al., 2007).
- A study in Brazil steel plant by Schoemaker et al. (2000) reported higher work injury rate among young workers aged below 25 years.
- A review on work injury literature reveals that 56% of the work injury studies conclude higher non fatal work injury rate for young workers and 17% studies concludes on lower work injury rate among young workers (Salminen, 2004).
- A study on fatal and non fatal work injuries in Korean manufacturing industry concludes that work injury risk increases with age (Fotta and Bockosh, 2000).

- Comprehensive review on work injuries by Salminen (2004) and Khanzode et al. (2012) reveal inconclusiveness in age and work injury relationship.
- A study on age and work injury relationship observed an inverted U pattern where work injury risk increases up to 25 years age, becomes stable during middle age and decreases during higher age (Lamme and Menckel, 1995).

The above evidences suggest the need of investigating the influence of age on work place injuries and hence it was decided to include “age” as a factor in this study.

#### *3.4.2.2 Experience*

Experience represents the amount of time an employee is engaged in his/her job. It is expected that experienced employees can perceive their jobs more accurately than an inexperienced employee. At the same time, experienced workers are likely to be exposed to hazardous environment for a longer period of time that may increase the chance of meeting with injuries.

- The concept of familiarity and perception of hazards dictates that experience should have negative relation with work injury (Basha, 2012).
- An exploratory study on safety climate and safety behavior reveals significant relationship between experience and work injury (Cooper and Philips, 2008).
- Studies on work injuries in mines report no relationship between experience and work injury (Maiti and Bhattacherjee, 1999; Breslin et al., 2007).

It is likely that experienced workers have more safety control as they are more familiar with the hazards present and know how to avoid hazardous situations than a less experienced worker.

Based on above facts 'experience' is included as a factor in this research.

### 3.4.3 Employment factors

#### *3.4.3.1 Working hours*

Globalization in the market requires firms to be flexible and ready to make rapid changes in its working pattern (Quinlan et al., 2000). For a worker in a developing country, changes in working pattern probably refers to an increase in shift work or extended working hours that has higher likelihood of influence on work injuries.

- A review on the influence of regular and extended working hours on work injuries concludes on elevated risk of work injuries during extended working hours in USA, but not in other countries (Salminen, 2010).
- A study on work injuries on 28 power plant workers employed in regular working hours (8 hours) and extended working hours (>8 hours) reported no significant difference in work injury experience (Axlesson et al., 1998).
- Evidences of increased work injury due to extended working hours is found in specific occupations like nurses (Macias et al., 1996), miners (Duchon and Smith, 1994), anesthetists (Gander et al., 2000), truck drivers (Mccart et al., 2000), veterinarians (Trimpop et al., 2000), construction workers (Lowery et al., 1998) and nuclear power plant operators (Baker et al., 1994)

Above studies conclude on increased risk of work injuries for workers who worked in extended working hours than in regular working hours.

Based on above facts, 'working hours', whether working for 8 hours or more than 8 hour (extended working hours) is selected as factor in this study.

### *3.4.3.2 Shift work*

Some of the published studies shows increased work injury during shift work

- In a review of studies related to work injury and shift work, Salminen (2010) revealed that eight out of nineteen studies reported increase in frequency of work injuries during night shifts.
- A study on metallurgical plant in GDR reports that frequencies of work injuries reaches maximum during night shifts (Vegaso et al., 2007).
- An investigation on Dutch bus drivers reported increased work injury frequency during night shifts than morning shifts (Pokorny, 1987).
- A study on Norwegian drilling rig operators reported more injuries during the day shift than during the night shift (Laurdisen, 1990).

Based on above facts, 'shift work', whether working in shifts or non shift (general shift) is selected as a factor in this study.

### *3.4.3.3 Nature of employment*

Global expansions of business have brought new form of conditional work arrangement. The arrangement of this kind outsources contract/adhoc workers for executing work during peak order of customer demand and lets off their role during the lean period. This practice is to offset labour cost during lean production period and offers flexibility in employment terms for employers (See sec 3.3). These forms of work arrangement characterize features of precarious employment like, e.g., lack of formal training, deviating from safety practices, higher and unregulated physical workload etc (Quinlan et al., 2001).

- High prevalence of work injuries is found to be associated with welders recruited through adhoc employment (Ganesh and Priya, 2014).

- A study on relation between work injuries and workers recruited through adhoc employment reveals adhoc workers are more exposed to higher work injury risk than regular/permanent workers. The study concludes on lack of effective experience combined with job security as reasons for higher work injury risk among adhoc workers (Saha et al., 2005).

Based on above facts 'nature of employment' – whether recruited on regular rolls or on contract/adhoc rolls is selected as factor in this study.

#### *3.4.3.4 Mode of apprenticeship training*

The welder population charteristic (See sec 3.3) can be considered as similar to that of precarious employment (Quinlan et al., 2001). Welding process is a labour intensive trade that attracts young men. Further, it serves as an avenue for demonstrating their boldness and dissipating their latent youthful energy (Ekpo, 2012). Studies have shown that welding as a vocation provides income for unskilled and semiskilled people in the society who could otherwise remain jobless (Ekpo, 2012; Nwaka, 2008). Welding, as an informal vocation, is a means of livelihood mainly for people of low educational status of the society. Analyzing the issue of specific years of formal institutional training requirement for welders, it is found that most of the welder apprentices spend several years of learning to perfect their skills in an informal setting while few learnt it while watching their relations (welders) in their job shop for few months (Hamel, 2011). A study on south Indian coastal welders indicate that lack of institutional training exposes welder to higher work injury risk (Ganesh and Priya, 2014).

Based on above facts, 'Mode of apprenticeship training' – whether a welder is trained on-the-job or institution trained is selected as factor in this study.

### *3.4.3.5 Physical workload*

A study on hotel room cleaners indicates a strong association between physical workload and work injury (Niklas Krause et al., 2005). A comparative study of office clerks, fishermen and manual metal arc welders shows welders are more prone for dynamic and static physical workload which increases work injury risk (Toner et al., 1991). A biomechanical study on welders reveals that welders are more prone to physical static and dynamic workload or combined loads due to deviation in ergonomic principles. The study concludes with note to design tools for welders based on ergonomic principles (Kadefors et al., 1997). A study on hospital nurses concludes on higher physical workload as a cause for the musculoskeletal work injuries (Josephine et al., 1996). Based on above facts 'physical workload' is selected as a factor in this study.

For calculating physical workload of welders, the respondents were asked to specify the diameter and average number rods used during last one month for their welding work. The responses were then converted into Kilograms of metal deposit for calculating the physical workload.

### 3.4.4 Work factor domains in fabrication environment

Any production environment comprises of energy interactions among various work factor in the workplace. Analyzing standardized instruments available in published literature to measure work factors reveal that they are either limited in their extent by physical work factors or nonphysical work factors in the work environment.

Work Factors Analysis (WFA) is a methodology that classifies physical and nonphysical factors that impacts worker performance in a work environment (Genaidy et al., 2000). WFA also provides guidelines for classifying physical and nonphysical factors in different types of work environment/workplace. At present, there is scarcity of instrument to measure work factors in a fabrication environment. In such situation, it is customary for the researcher to design a measuring instrument to capture the variables in line with the objectives of the research. Therefore, the WFA methodology is adopted in this study for classifying the work factor domains and their charteristic items in the fabrication environment.

The fabrication work environment is classified on the basis of WFA methodology (See Appendix Figure AF7 to AF14) into eight work factor domains. These domains contain two energy levels: expenditure and replenishment of energies.

- Expenditure energy is the energy expended by a work factor domain from the welder.
- Replenishment energy is the energy through which a work factor domain replenishes the welder.

It is conceptualised that a fabrication work environment contains many work factor domains, which have energy interactions between them (Genaidy et al., 2000). Work factor domains present in the fabrication work environment transfers work injury risk into work injury incident. Energy interactions between work factor domains during work injury event dictate how energy transfers to welder body in its vicinity and degree of severity. For an injury free performance in the fabrication work environment the energy interactions between work factor domains should be equal and any mismatch among them will lead to work injury of varying frequency and severity.

Based on WFA classification eight work factor domains were selected for the study.

- Health perception: welding as a labour intensive vocation serves as an avenue for demonstrating boldness and dissipating their latent youthful energy for young men which provides income for skilled and unskilled people in the society who could other wise remain jobless (Ekpo, 2012; Nwaka, 2008). Hence, this vocation in turn depends on the health perception of the individual. The low level of education might be one of the reasons for their low compliance to the use of safety devices. An illiterate person do not usually attach much importance to devices that could guarantee their personal safety in dangerous adventures (Karwowski, 2006; Genaidy et al., 2000).
- Safety culture: good safety culture leads to low work injury rates in the work environment. Moreover as results of legislative restriction, the worker needs to follow certain work practices, which in turn nurtures safety culture. But, the safety culture of the firms is influenced by the firms polices, peer groups, practical difficulty and attitude of the work force (Vinodkumar and Bhasi, 2009).
- Physical task content: a worker involved in fabrication environment repeatedly use gripping force in awkward body postures that include standing, squatting, crawling, couching and depends on visual cues to execute the work (Genaidy et al., 2000).
- Mental task content: workers use their senses for cues that include visual differentiation, sound differentiation, posture adjustment for executing work and quality, interpretation of the given information, on the spot decision, intricativeness of the job and planning in par with scheduling plans (Genaidy et al., 2000).
- Physical environment: an industrial fabrication environment comprise of noise, vibration, heat generated during weldment process, static and

dynamic supports for fabricating structures and splinters from the welding process (Genaidy et al., 2000).

- Social environment: role of social support and its relation to work injuries is less understood than work related physical risk factors, such as manual welding task, lifting and repetitive movements in fabrication environment. In a work environment social support is generally enhanced by the supervisor support, relationship with peers together with clarity in their communications, general relationship with coworkers at work and these measures are frequently assessed in work injury related studies (Woods, 2005; Genaidy et al., 2000)).

- Technical environment: welders employed in industrial fabrication units generally face issues related to scientific planning due fixed infrastructure and varying customer requirements. These issues are related to job sequencing, availability of right tools, logical arrangement of layouts, learning from technically different configurations and technical demand among welders for doing auxiliary work. (Occupational analysis of welder, 2009; Genaidy et al., 2000).

- Perceived benefit: welding trade as vocation provides a means of livelihood for many in the region (CSR perceptions and activities of small and medium enterprises in seven geographical clusters UNDIO survey report, 2008). Hence, income security and wage related to the fabrication work were considered in this work factor domain (Karwowski, 2006; Genaidy et al., 2000).

Initially, questionnaire with 100 questions were selected from the published literature to suit the eight work factor domains. After consultation with the welders, supervisors, safety professionals and academicians, ten questions were removed. The questionnaire contained 90 characteristic items identified under eight work factor domains evoking response on five point Likert scale. This scale sensitivity ensured welders response included their adjustment for the vagueness and variability with fixed facilities in their work place.

The pilot study was administered to 50 welders employed by firms in the EFC during their working hours after assuring anonymity. that results would be used only for academic purpose. After collecting data, reliability analysis was carried out for all charteristic the items under study in their respective work factor domains. The charteristic items having inter item correlation value less than 0.3 were excluded from the questionnaire. This resulted in discarding 21 characteristic items. Confirmatory factor analysis was performed for 69 characteristic items in their respective work factor domains. A factor loading value greater than 0.3 was considered significant (Brown et al., 1986; Rahuman, 2000). This resulted in deletion of 25 characteristic items. Thus empirical validation resulted in forty four charteristic (See Table A1) items to be included under eight work factor domains section of the questionnaire.

**Table 3.1** Work factor domains and their characteristic items before and after pilot study

| Sl No | Work factor domain | Number of characteristic items before pilot study | Number of characteristic items after pilot study |
|---|---|---|---|
| 1 | Health perception | 10 | 4 |
| 2 | Safety culture | 20 | 11 |
| 3 | Physical task content | 10 | 4 |
| 4 | Mental task content | 10 | 8 |
| 5 | Physical environment | 10 | 6 |
| 6 | Social environment | 10 | 4 |
| 7 | Technical environment | 10 | 5 |
| 8 | Perceived benefit | 10 | 2 |
| | Total | 90 | 44 |

The Table 3.1 shows the number of characteristic item before and after pilot study. Eight work factor domains and final characteristic items with their reliability values with their sources are shown in (Appendix Table. AT.1).

### 3.4.5 Modified version of standardized nordic questionnaire for measuring musculoskeletal disorder symptoms

To measure musculoskeletal disorder symptoms among the welder population Modified Standarised Nordic questionnaire (MSNQ) proposed by Dickinson et al. (1992) is used for the study. This section of the questionnaire contains a sketch of a human marked with nine body regions. The body regions are defined and shaded: (neck, shoulder, upper back, elbows, wrist hands. hips/thighs /buttock, ankle, and feet), requesting yes or no response on pain for each body region during three periods: weekly prevalence annual prevalence and annual disability (discomfort).

## 3.5 VALIDITY ANALYSIS OF THE QUESTIONNAIRE

The work factor domain section of the survey questionnaire was customized for fabrication industry, hence required empirical validation for meaningful analysis. Statistical programs SPSS 16 and AMOS package were used for the analyses. The questionnaire was checked for different types of validity and reliability and is explained in the following sections.

- Content validity,
- Face validity
- Convergent validity
- Unidimensionality

### 3.5.1 Content validity

Content validity of an instrument refers to the degree to which it provides an adequate depiction of the conceptual domain that it is designed to cover (Hair et al., 1998). In the case of content validity, the evidence is subjective and logical, rather than statistical. Establishment of content validity warrants sound logic, good intuitive skills and high perseverance on the part of the instrument designer (Kaplan and Scauzzo, 1993). Content validity can be ensured if the items representing the various constructs of an instrument are substantiated by a comprehensive review of the relevant literature (Bohrnstedt, 1983).The present instrument has been developed on the basis of detailed review and analysis of the prescriptive, conceptual, practitioner and empirical literature, so as to ensure the content validity.

### 3.5.2 Face validity

Generally, a measure is considered to have 'face validity' if the items are reasonably related to the perceived purpose of the measure (Kaplan and Scauzzo, 1993). Face validity is the subjective assessment of the correspondence between the individual items and the concept through rating by expert judges (Hair et al., 1998). In face validity, one looks at the measure and judges whether it seems a good translation of the construct under study. Face validity is also a subjective and logical measure, similar to content validity. The face validity can also be established through review of the instrument by experts in the field (Hair et al., 1998). The present questionnaire has been given to four supervisors, three fore man and five welders employed by firms in the fabrication cluster. They were briefed about the purpose of the study and its scope. The welder trade experts have been requested to scrutinize the questionnaire and to give their impressions regarding the relevance and contents of the checklist questionnaire. They have also been asked to critically examine the questionnaire, and to give objective feedback and suggestions with regard to comprehensiveness/coverage, redundancy level, consistency and number of items in each variable. After considering each item in detail, necessary changes were made by simplifying, rewording, removing and replacing some of them. In the initial questionnaire, there were 100 characteristic items. Based on the feedback from experts 10 items were dropped and 90 questions were retained in the questionnaire for the pilot study. It may be noted that the content validity and face validity have been assured in the initial stages of questionnaire development itself.

### 3.5.3 Convergent validity

The evidence for 'convergent validity' is obtained when a measure correlates well with other measures that are believed to measure the same construct (Kaplan and Scauzzo,1993). In other words, convergent validity is the degree to which the various approaches to construct measurements are similar to (converge on) other approaches that they theoretically should be similar to (Sureshchander et aI., 2001). It can also be seen that each item in a scale is treated as different approach to measure the construct (Hair et aI., 1998). Using confirmatory factor analysis technique, the convergent validity of the questionnaire is checked with the help of a coefficient called Bentler Bonett Fit Index (NNFI or TLI). A scale with TLI values of 0.9 or above is an indication of strong convergent validity (Bender and Bonett, 1980). The values of all the measures are summarized in Table 3.2.

**Table 3.2** Results of confirmatory analysis: unidimensionality, convergent validity, and reliability coefficient for work factor domains

| Sl No | Work factor domain | Number of items | CFI | Cronbach's alpha(α) | Tucker Lewis fit index |
|---|---|---|---|---|---|
| 1 | Health perception | 4 | 0.881 | 0.742 | 0.871 |
| 2 | Safety culture | 11 | 0.912 | 0.713 | 0.891 |
| 3 | Physical task content | 4 | 0.894 | 0.685 | 0.893 |
| 4 | Mental task content | 8 | 0.879 | 0.616 | 0.898 |
| 5 | Physical environment | 6 | 0.913 | 0.692 | 0.905 |
| 6 | Social environment | 4 | 0.891 | 0.723 | 0.887 |
| 7 | Technical environment | 5 | 0.892 | 0.686 | 0.891 |
| 8 | Perceived benefit | 2 | 0.913 | 0.672 | 0.907 |
| | Overall fit | 44 | 0.899 | | 0.902 |

The result of confirmatory factor analysis in Table 3.2 TLI values (0.88-1.00) (Ory and Mokhtarain, 2012) shows strong convergent validity.

### 3.5.4 Unidimensionality analysis

Unidimensionality is related to single construct /trait underlying a set of measures (Hair et al., 1998). The fundamental assumption in measurement theory is that a set of items should measure one thing in common. Items related to a measure are useful only to the extent they share a common nucleus (Nunnally, 1978). Computing the comparative fit indices (CFI) indicates a closer value of 0.9 in Table 3.2 which indicates stronger evidence towards unidimensionality. In many occasions, unidimensionality alone cannot substantiate the usefulness of the scale. For further validation analysis, reliability has to be computed. (Sureshchander et al., 2001).

### 3.5.5 Reliability analysis

Reliability of an instrument is defined as the extent to which any measuring instrument yields the same result on repeated trials (Cannines and Zeller, 1990). It is the degree to which the instrument yields a true score of the variable (factor) under consideration. The instrument is not considered as reliable to the extent to which it contains measurement error (Neale and Liebert, 1986). There are several methods to establish the reliability of a measuring instrument. These include test retest method, equivalent forms, split halves method, and internal consistency method. These methods are based on theories such as true and error scores, parallel forms and domain sampling. Of all these methods, the internal consistency method is considered to be the most effective method, especially in field studies. The advantage of this method is that it requires only one administration, and consequently this method is considered to be the most general form of reliability estimation (Sureshchandar et al., 2001). In this method, reliability is operationalized as 'internal consistency', which is the degree of inter correlation among the items that constitute the scale (Nunnally, 1978). Internal consistency of a set of items thus refers to the homogeneity of the items in a particular scale. The internal consistency is estimated using a reliability coefficient called Cronbach's alpha (a) (Cronbach, 1951). An alpha value of 0.70 or above is considered as the criterion for demonstrating strong internal consistency of established scales (Nunnally, 1978). In the case of exploratory research, alpha value of 0.60 or above is also considered as significant (Hair et al., 1998). The Table 3.2 shows α values above 0.6, which is above the specified ranges that ensured reliability and validity measures of work factor domain section in the questionnaire.

## 3.6 DATA COLLECTION AND SAMPLING

Initially, firms in the fabrication cluster were reluctant to allow their welders to participate in the survey. The survey was conducted after persuading proprietors and welders with the help of small scale industry association members and vendor trade associations on anonymity and assuring that survey results will be used only for academic purpose. The survey participants were explained about the purpose of the survey and informed that their participation was voluntary and responses will be kept confidential. The four page questionnaire was distributed to randomly selected welder participants in different firms located in the EFC.

The questionnaire was prepared in English and translated into the local dialect. For ensuring clarity, the researcher was present while administering the survey in the cluster. The duration of the survey was around 28 months as survey participants took their convenient time to mark their responses. Around 2225 questionnaires were distributed among welders, only 1440 filled in questionnaires were collected back, a return ratio of (65%). The sample size and return ratio are exhibited in Table 3.3.

**Table 3.3** Sample size and response rate

| Firm | Number of questionnaires given | Number of questionnaires returned | Return ratio% |
|---|---|---|---|
| 1 | 100 | 69 | 69 |
| 2 | 60 | 45 | 75 |
| 3 | 80 | 60 | 75 |
| 4 | 130 | 93 | 72 |
| 5 | 130 | 96 | 74 |
| 6 | 120 | 99 | 83 |
| 7 | 100 | 74 | 74 |
| 8 | 100 | 81 | 81 |
| 9 | 150 | 92 | 61 |
| 10 | 100 | 89 | 89 |
| 11 | 120 | 102 | 85 |
| 12 | 150 | 98 | 65 |
| 13 | 100 | 74 | 74 |
| 14 | 250 | 158 | 63 |
| 15 | 120 | 90 | 75 |
| 16 | 80 | 43 | 54 |
| 17 | 100 | 37 | 37 |
| 18 | 90 | 65 | 72 |
| 19 | 70 | 48 | 69 |
| 20 | 75 | 70 | 93 |
| **Total** | **2225** | **1440** | **64.71** |

Analyzing the participant data, only 1075 (74%) questionnaires were found to be useful for analysis.

## 3.7 DATA PREPARATION AND ANALYSIS

The collected data was processed to check the completeness of the filled in information. The database in SPSS spreadsheet was created after cleaning and coding the data. The coded data was checked for outliers, missing data and errors. Finally, the statistical assumptions like independent observation, normality and homogeneity of variance required for parametric tests were checked in the data. The results showed no abnormal deviations in the distribution and hence the data was considered suitable for the analysis.

## 3.8 DISCUSSION ON RELATIONSHIP AMONG VARIOUS FACTORS

Published literature for work injuries reveals dearth of literature related to the individual, employment and work factors influencing pain frequencies due to NRHFLS work injuries among welders. Most of the welder work injury studies relate to epidemiological studies. Manual metal arc welding is a traditional process for fabrication industry, only few studies address welding process hazards for example, inhaling of fumes, improper usage of safety devices, risk communication, musculoskeletal disorder pain and long term chronic effect that influences disability which cause harm to the welders. The most commonly studied causal factors in accident, safety and work injury literature are personal attributes, employment factors and work factors considering reported work injuries. Present study attempts to analyze the influence of these factors on pain frequencies due to NRHFLS work injuries among welders employed by fabrication firms located in an engineering fabrication cluster. For a better view of the relationship between factors considered in the study and the pain frequencies due to NRHFLS work injuries, a bivariate correlation analysis was performed. The results are shown in Table 3.4 and their interpretation is as follows

**Table 3.4:** Bivariate correlation values between NRHFLS work injuries and personal attributes, employment factors, work factor domains`

| | NWI | AGE | EXP | WH | SW | NE | MAT | PWL | HP | SC | PTC | MTC | PE | SE | TE | PB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NWI | 1 | .52** | -.36** | .40** | .70** | .45** | .43** | -.60** | .38** | -.45** | -.37** | .09 | -.32** | -.44** | -.15** | -.24** |
| AGE | | 1 | .30** | -.08** | .20* | .01 | .08** | -.14** | .11** | -.10** | .07* | .00 | -.05 | -.12 | -.03 | -.041 |
| EXP | | | 1 | .06** | .07* | .010 | -.04* | .030 | .01 | .08** | .040 | .00 | .010 | .03 | .03 | .063* |
| WH | | | | 1 | -.60 | -.21** | -.38 | .45** | .27** | .39** | .30** | .04 | .21** | .36** | .11* | .20** |
| SW | | | | | 1 | .40** | .50** | -.84** | .54** | .61** | -.55* | -.07* | .38** | .63** | -.19** | -.31* |
| NE | | | | | | 1 | .22** | -.31** | .26** | -.23 | -.16** | .00 | -.04 | -.18 | -.09 | -.08 |
| MAT | | | | | | | 1 | -.40** | .24* | -.34** | -..28** | .04* | -.23** | -.29 | .11** | -.16* |
| PWL | | | | | | | | 1 | .50* | .53** | .50** | .06* | .30** | .50** | .16** | .25** |
| HP | | | | | | | | | 1 | -.17** | -.17** | .14** | 0.40 | -.21** | .60 | -.12** |
| SC | | | | | | | | | | 1 | .53** | .21** | .45** | .55** | .23** | .30** |
| PTC | | | | | | | | | | | 1 | .19** | .39** | .47** | .20** | .29** |
| MTC | | | | | | | | | | | | 1 | .14** | .15** | .80 | .10* |
| PE | | | | | | | | | | | | | 1 | .36** | .15** | .23** |
| SE | | | | | | | | | | | | | | 1 | .18** | .28** |
| TE | | | | | | | | | | | | | | | 1 | .10* |
| PB | | | | | | | | | | | | | | | | 1 |

Significance level **p < 0.01; *p < 0.05; NWI - Non-Reported high frequent low severe work injuries, AGE - Age, EXP-Experience as welder, WH-Working Hours, SW-Shift Work, NE-Nature of Employment, MAT-Mode of Apprenticeship Training, PWL-Physical Work Load, HP-Health perception, SC-Safety culture, PTC - Physical Task Content, MTC-Mental Task Content, PE-Physical Environment, SE-Social Environment, TE-Technical Environment, PB-Perceived Benefit

Personal attributes: NRHFLS work injuries are positively correlated to age (r = 0.52, p < .01, N = 1075, $R^2$ = 0.27) and negatively correlated to welder experience (r = -0.36, p < .01, N =1075, $R^2$ = .13). The $R^2$ value reveals more than 25% of unexplained variance between the variables, which makes them appropriate for the study.

Employment factors: NHRFLS work injuries are positively correlated to working hours (r = .0.40, p <. 01, N = 1075, $R^2$ = 0.16), shift work (r = 0.70, p <. 01, N = 1075, $R^2$ = 0.49), nature of employment (r = 0.45, p < .01, N = 1075, $R^2$ = 0.20), mode of apprenticeship training (r = 0.43, p < .01, N = 1075, $R^2$ = 0.18) and negatively correlated to physical workload (r = -0.60, p < .01, N = 1075, $R^2$ = 0.13). The $R^2$ value reveals more than 25% of unexplained variance between the variables, which makes them suitable for the study.

Work factor domains: NHRFLS work injuries are positively correlated to heath perception (r = 0.38, p < .01, N = 1075, $R^2$ = 0.14) and negatively correlated to safety culture (r = -0.45, p < .01, N =1075, $R^2$ = 0.20), physical task content (r = -0.37, p < .01, N = 1075, $R^2$ = 0.14), physical environment (r = -0.32, p < .01, N = 1075, $R^2$ = 0.10), social environment (r = -0.44, p < .01, N = 1075, $R^2$ = 0.19), technical environment (r = -0.15, p < .01, N = 1075, $R^2$ = 0.02), perceived benefit (r = -0.24, p < .01, N = 1075, $R^2$ = 0.05). The correlation between NRHFLS work injuries and mental task content (r = 0.09, p > .01, N = 1075) is not significant. The significant r value between variables revealed that more than 25% of unexplained variance is present and hence considered appropriate for the study.

## 3.9 SUMMARY AND CONCLUSIONS

The study in its endeavor designs an instrument to measure personal attributes, employment factors, work factor domains, musculoskeletal disorder and welder specific physical work injuries that have influence on NRHFLS work injuries.

The result of this part of the study:

- Attempts to measure the pain frequencies due to NRHFLS work injuries among welders employed in the fabrication industry.
- Identifies personal attributes for measuring pain frequencies due to NRHFLS work injuries related to welders work in the fabrication industry.
- Identifies employment factors for measuring pain frequencies due to NRHFLS work injuries related to welders work in the fabrication industry.
- Identifies and empirically validates work factor domains and its characteristic items for manual metal arc welders employed in the fabrication industry.
- Attempts to identify and measure work related musculoskeletal disorder pain in the nine body regions of welders employed in the fabrication industry.

The factors considered in this study can supplement the resource lean welders' work injury literature.

*Chapter* **4**

# INFLUENCE OF PERSONAL ATTRIBUTES AND EMPLOYMENT FACTORS ON PAIN FREQUENCIES DUE TO NON REPORTED HIGHLY FREQUENT LESS SEVERE WORK INJURIES AMONG WELDERS

*Contents*



## 4.1 INTRODUCTION

The study presented in this chapter was carried out the with the following objectives

- To analyse the descriptive statistics of welders employed in organized and unorganized sector firms in engineering fabrication cluster.
- To compare the mean pain frequencies due to non reported highly frequent less severe work injuries among welders employed in organized and unorganized sector firms in the engineering fabrication cluster.

- To identify the impact of personal attributes that influence pain frequencies due to non reported highly frequent less severe work injuries among welders employed in organized and unorganized sector firms in engineering fabrication cluster.
- To identify the employment factors that influence pain frequencies due to non reported highly frequent less severe work injuries among welders employed in organized and unorganized sector firms in engineering fabrication cluster.
- To compute the effect size for finding the magnitude of difference between identified significant employment factor levels for prioritizing and targeting intervention initiatives to mitigate pain frequencies due to non reported highly frequent less severe work injuries among welders employed in organized and unorganized sector firms in engineering fabrication cluster.

## 4.2 DESCRIPTIVE ANALYSIS OF WELDERS' DATA

The welder population employed by firms in Engineering Fabrication Cluster (EFC) considered in this study is dichotomized into two sectors – Organized Sector Fabrication (OSF) firms and Unorganized Sector Fabrication (USF) firms and the analysis is carried out in the following sections.

### 4.2.1 Distribution of sector wise welder population

The Table 4.1 shows the details of the surveyed population.

**Table 4.1** Welders – sector wise classification

| Sector wise employment | OSF | USF | EFC |
|---|---|---|---|
| | $n_1 = 692$ | $n_2 = 383$ | N = 1075 |
| Percentage | 64.40 | 35.60 | 100 |

**Interpretation:** Out of the 1075 welders, who participated in the study, OSF firms employed 64.40% of the welders and 35.60% of the welders were employed by USF firms.

### 4.2.2 Sector wise distribution of pain frequencies due to NRHFLS work injuries among the welder population

The Table 4.2 shows the details of sector wise distribution of mean pain frequencies due to NRHFLS work injuries among the welder population employed by firms in the EFC:

**Table 4.2** Pain frequencies due to NRHFLS work injuries – sector wise

| NHRFS work injury exposure | OSF $n_1$= 692 | | USF $n_2$= 383 | | EFC N = 1075 | |
|---|---|---|---|---|---|---|
| | $M_2$ | SD | $M_3$ | SD | $M_1$ | SD |
| Frequency | 3.86 | 1.13 | 6.78 | 1.83 | 4.90 | 1.99 |

**Interpretation:**

- Welder population employed by firms in EFC experience pain frequencies due to NRHFLS work injuries in a range of minimum two to a maximum of twelve frequencies with a mean and standard deviation of (4.90 $\pm$ 1.99) frequencies.
- Welders employed by OSF firms experience pain frequencies due to NRHFLS work injuries in a range of minimum two frequencies to a maximum of eleven frequencies with a mean and standard deviation of (3.86 $\pm$ 1.13) frequencies.
- Welders employed by USF firms experience pain frequencies due to NRHFLS work injuries in a range of minimum of two frequencies to a maximum of twelve frequencies with a mean and standard deviation of (6.78 $\pm$ 1.83).

On comparison, welders employed by USF firms experience higher pain frequencies due to NRHFLS work injuries than welder population employed by firms in EFC and welders employed by the OSF firms.

### 4.2.3 Sector wise distribution of personal attributes among the welder population

#### *4.2.3.1 Personal attribute: age*

The Table 4.3 shows the details of sector wise distribution of mean age in years among the welder population employed by firms in the EFC.

**Table 4.3** Mean age of welders – sector wise

| Personal attribute | OSF $n_1$= 692 | | USF $n_2$= 383 | | EFC N = 1075 | |
|---|---|---|---|---|---|---|
| | **M** | **SD** | **M** | **SD** | **M** | **SD** |
| Age | 33.60 | 11.15 | 37.30 | 11.31 | 34.92 | 11.34 |

**Interpretation:**

- Welder population employed firms in EFC are aged in the range of minimum 16 years to a maximum of 57 years with a mean and standard deviation of (34.92 $\pm$ 11.34) years.
- Welders employed by OSF firms are aged in the range of minimum 18 years to a maximum of 54 years with a mean and standard deviation of (33.60 $\pm$ 11.15) years.
- Welders employed by USF firms are aged in the range of minimum 16 years to a maximum of 57 years with a mean and standard deviation of (37.30 $\pm$ 11.31) years.

On comparison, it is seen that the mean age of the welders in USF firms is higher than that of the total sample and than in OSF firms.

#### 4.2.3.2 *Personal attribute: experience as welder*

The Table 4.4 shows the details of sector wise distribution of mean welder experience in years among the welder population employed by firms in EFC

**Table 4.4** Experience of welders in years – sector wise

| Personal attributes | OSF $n_1$= 692 | | USF $n_2$= 383 | | EFC N = 1075 | |
|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD |
| Experience as welder | 12.20 | 8.29 | 10.98 | 7.60 | 11.77 | 8.07 |

**Interpretation:**

- Welders in EFC have experience in the range of minimum 1 year to a maximum of 29 years with a mean and standard deviation of (11.77 $\pm$ 8.07) years.
- Welders employed by OSF firms employ experienced welders in the range of 1 to 27 years with a mean and standard deviation of (12.20 $\pm$ 8.29) years.
- Welder employed by USF firms employs experienced welders in the range of 1 to 29 years with a mean and standard deviation of (10.98 $\pm$ 7.60) years.

On comparison, welders in OSF firms are found to have higher mean experience than the total sample and welders employed in USF firms.

### 4.2.4 Sector wise distribution of employment factors among the welder population in EFC

#### 4.2.4.1 *Employment factor: working hours*

The Table 4.5 shows the details of sector wise percentage distribution of working hours among the welder population employed by firms in EFC.

**Table 4.5** Working hours of welders – sector wise

| Working hours | OSF $n_1 = 692$ | | USF $n_2 = 383$ | | EFC N= 1075 | |
|---|---|---|---|---|---|---|
| | **Frequency** | **%** | **Frequency** | **%** | **Frequency** | **%** |
| = 8 hrs | 239 | 35 | 360 | 94 | 599 | 55 |
| > 8 hrs | 453 | 65 | 23 | 6 | 476 | 45 |

**Interpretation:**

- Out of the total sample of 1075 welders, 55% work only during regular working hours ( 8 hours) and 45% are engaged extended working hours (more than 8 hours) during day.
- Out of 692 welder participants employed by OSF firms, 35% of the welders have reported to have engaged in regular eight hours work and 65 % of the welders have reported to have engaged in more than eight hours work.
- Out of 383 welder participants employed by USF firms, 94% of the welders have reported to have engaged in regular eight hours work and 6% of the welders have reported to have engaged in more than eight hours work.

Welders in USF firms are more associated with regular eight hours work than welders employed by OSF firms. Though welders employed by USF firms sparsely work in extended working hours for completing the allocated job, they are not entitled to increased pay. Further major percentage of the welders employed by OSF firms is engaged in more than eight hours work.

### *4.2.4.2 Employment factor: shift work*

The Table 4.6 shows the details of sector wise percentage distribution of welders engaged in shift work among the welder population employed by firms in EFC.

**Table 4.6** Shift work of welders – sector wise

| Shift work | OSF $n_1 = 692$ | | USF $n_2 = 383$ | | EFC N= 1075 | |
|---|---|---|---|---|---|---|
| | **Frequency** | **%** | **Frequency** | **%** | **Frequency** | **%** |
| Work in shifts | 692 | 100 | - | - | 692 | 64.4 |
| Non shift work | 0 | - | 383 | 100 | 383 | 35.6 |

**Interpretation:**

- Out of 1075 welders participants, 64.4% of the welders are attached to shift work and 35.6% of the welders work in day time during the general shift. The shift work is a prevalent only among welders employed by OSF firms.

### *4.2.4.3 Employment factor: nature of employment*

The Table 4.7 shows the details of sector wise percentage distribution of welders for nature of employment among the welder population employed by firms in EFC.

**Table 4.7** Nature of employment of welders – sector wise

| Nature of employment | OSF $n_1 = 692$ | | USF $n_2 = 383$ | | EFC N= 1075 | |
|---|---|---|---|---|---|---|
| | **Frequency** | **%** | **Frequency** | **%** | **Frequency** | **%** |
| Regular | 258 | 37.3 | 9 | 2.3 | 267 | 24.8 |
| Adhoc | 434 | 62.7 | 374 | 97.7 | 808 | 75.2 |

- Out of 1075 welder participants 24.8% of the welders reported recruitment through regular employment rolls and 75.2% have reported recruitment through contract/adhoc employment.
- Out of 692 welder participants employed by the OSF firms, 37.3% of the welders have reported recruitment through regular employment rolls and 62.7% have reported recruitment through contract/adhoc employment.

- Out of 383 welder participants employed by the USF firms, 2.3% of the welders have reported recruitment through regular employment rolls and 97.7% have reported recruitment through contract/adhoc employment.

Majority of the welder population employed by the firms in EFC are recruited through contract/adhoc nature of employment. Moreover, only sparse percentage of regular employment is prevalent among welders employed by USF firms.

#### *4.2.4.4 Employment factor: mode of apprenticeship training*

The Table 4.8 shows the details of sector wise percentage distribution of welders for mode of apprenticeship training among the welder population employed by firms in EFC.

**Table 4.8** Mode of apprenticeship training among welders – sector wise

| Mode of apprenticeship training | OSF $n_1 = 692$ | | USF $n_2 = 383$ | | EFC N= 1075 | |
|---|---|---|---|---|---|---|
| | Frequency | % | Frequency | % | Frequency | % |
| Institutional (ITI certificate) | 345 | 49.9 | 5 | 1.4 | 350 | 32.6 |
| On-the-job training | 347 | 50.1 | 378 | 98.6 | 725 | 67.4 |

**Interpretation:**

- Out of 1075 welder participants employed by the firms in EFC, 67.4% of the welders reported to have acquired the welder trade knowledge through on-the-job-training methods and 32.6% reported to have acquired the welder trade knowledge through institutional methods.
- Out of 692 welder participants employed by the OSF firms, 50.1% of the welders reported to have acquired the welder trade knowledge through on-the-job-training methods and 49.9% reported to have acquired the welder trade knowledge through institutional methods.

- Out of 383 welder participants employed by the USF firms, 98.6% of the welders have to have acquired the welder trade knowledge through on-the-job-training methods and only 1.4% reported to have acquired the welder trade knowledge through institutional methods.

Welder trade knowledge acquired by institutional training is sparsely associated with welders employed by USF firms. Comparatively a higher percentage of welders in the EFC population have acquired the welder trade knowledge through on-the-job-training methods.

#### *4.2.4.5 Employment factor: physical workload*

The Table 4.9 exhibits the descriptive statistics of sector wise distribution of physical workload among welders employed in EFC.

**Table 4.9** Physical workload of welders – sector wise

| Employment factors | OSF $n_1$= 692 | | USF $n_2$= 383 | | EFC N = 1075 | |
|---|---|---|---|---|---|---|
| | M | SD | M | SD | M | SD |
| Physical work load in Kg | 4.76 | 1.46 | 0.77 | 0.68 | 3.34 | 2.28 |

**Interpretation:**

- Welder population employed by firms in EFC execute physical workload –'metal deposit' in the range of minimum 0.31 Kg to maximum 6.50 Kgs with a mean and standard deviation of (3.34 $\pm$ 2.28) Kgs.
- Welders employed by OSF firms execute physical workload –'metal deposit' in the range of minimum 0.31 Kg to maximum 6.50 Kgs with a mean and standard deviation of (4.76 $\pm$ 1.46) Kgs.
- Welders employed by USF firms execute physical workload –'metal deposit' in the range of minimum 0.38 Kg to maximum 1.98 Kgs with a mean and standard deviation of (0.77 $\pm$ 0.68) Kgs.

Higher mean physical workload 'metal deposit' is executed by welders employed by OSF firms than the welder population employed by firms in EFC.

## 4.3 COMPARISON OF PAIN FREQUENCIES DUE TO NRHFLS WORK INJURIES AMONG WELDERS SECTOR WISE

To compare the mean pain frequencies due to NRHFLS work injuries experienced by the welder population employed by firms in EFC and the welders employed by OSF and USF firms the following null hypothesis are set.

**$H0_{4\text{-}1}$:** There is no significant difference in mean pain frequencies due to NRHFLS work injuries experienced by the welder population employed by the firms in EFC ($M_1$) and welders employed by the OSF firms ($M_2$).

**$H0_{4\text{-}2}$:** There is no significant difference in mean pain frequencies due to NRHFLS work injuries experienced by the welder population employed by firms in EFC ($M_1$) and welders employed by the USF firms ($M_3$).

To test the null hypothesis $H0_{4\text{-}1}$ and $H0_{4\text{-}2}$ mean pain frequencies due to NRHFLS work injuries experienced by the welder population is hypothesized from Table 4.2 (M = 4.90). The difference in mean pain frequencies due to NRHFLS work injuries experienced by welders employed by OSF firms and hypothesized mean is tested by one sample t test. The results are shown in Table 4.10.

**Table 4.10** Comparison of mean pain frequencies due to NRHFLS work injuries between welder population and sector wise firms - Results of one sample t test

| Sample | t | df | Significance (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Test Value $M_1$ = 4.90 | | | | | | |
| OSF firms ( $n_1$) $M_2$ | -24.22 | 691 | .000** | -1.04 | -1.12 | -.96 |
| USF firms ($n_2$) $M_3$ | 20.03 | 382 | .000** | 1.88 | 1.69 | 2.06 |

**p < 0.01; *p < 0.05

**Interpretation:**

The one sample t test result $t(691) = -24.22$, $p < 0.01$ indicates mean pain frequencies due NRHFLS work injuries experienced by welders population employed in EFC is statistically significant and different to that of welder employed by OSF firms. Hence, null hypothesis $H0_{4}$-$_{1}$ is rejected and alternate hypothesis proposing the difference is accepted at 0.01 significance level.

The one sample t test result $t(382) = 20.03$, $p < 0.01$ indicates mean pain frequencies due NRHFLS work injuries experienced by welders population employed in EFC is statistically significant and different to that of welder employed by USF firms. Hence, null hypothesis $H0_{4}$-$_{2}$ is rejected and alternate hypothesis proposing the difference is accepted at 0.01 significance level.

The results shows that mean pain frequencies experienced by welders due to NRHFLS work injuries in the welder population and pain injury experience of welders employed in OSF and USF firms are statistically different.

## 4.4 COMPARISON OF PAIN FREQUENCIES DUE TO NRHFLS WORK INJURIES BETWEEN WELDERS EMPLOYED BY OSF AND USF FIRMS

To compare the mean pain frequencies due to NRHFLS work injuries between welders employed by OSF and USF firms the following null hypothesis are set.

**$H0_{4\text{-}3}$:** There is no significant difference in mean pain frequencies due to NRHFLS work injuries between the welders employed by OSF firms and USF firms.

To test the null hypothesis $H0_{4\text{-}3}$ Independent sample t test was performed. The results are shown in Table 4.11.

**Table 4.11** Comparison of mean pain frequencies due to NRHFLS work injuries between welders employed by OSF and USF firms. Results of independent sample t test

| Variable | Mean | SD | t # | df # | p |
|---|---|---|---|---|---|
| Firms | | | -28.30# | 547# | .000** |
| OSF firms | 3.86 | 1.20 | | | |
| USF firms | 6.78 | 1.83 | | | |

The #t and #df were adjusted because the variance were not equal; **$p < 0.0$; $p < 0.05$

**Interpretation:**

- The results in Table 4.11 shows that on an average, welders employed by USF firms (M = 6.78, SD = 1.20) experience higher pain frequencies due to NRHFLS work injuries than welders employed by OSF firms (M = 3.86, SD = 1.83). This difference is significant $t(547) = -28.30$, $p < 0.01$, d = 2.30. Hence, null hypothesis $H0_{4-3}$ is rejected alternate hypothesis proposing the difference is accepted at 0.01 significance level

The effect size d = 2.30 which is greater than 1 shows a very large magnitude of difference for pain frequencies due to NRHFLS work injuries experienced between welders employed by OSF and USF firms.

A very large effect size (Cohen, 1988) can be of practical importance to be considered for intervention initiatives among welders employed by OSF and USF firms.

## 4.5 PERSONAL ATTRIBUTES: IMPACT OF AGE ON PAIN FREQUENCIES DUE TO NRHFLS WORK INJURIES AMONG WELDERS EMPLOYED IN EFC, OSF AND USF FIRMS

It is generally believed that aged persons possess higher experience, hence they are likely to be more familiar with the job and have better control of their job that makes them less prone to work injuries. However, conflicting results are found in the literature regarding this relationship. For example, Maiti and

Bhattacherjee (1999) reported no relationship between age and work injuries among mine workers. A prospective study on the antecedents on work disability and absence among young people by Breslin et al. (2007) revealed no relationship between age and work injury. A review on the relation between age and work injury types reveals that work injury risk increases initially with age which remains unaffected in middle age and decreases with age that follows an inverted U tube pattern (Laamme and Mecknel, 1995). A review by Schoemaker et al. (2000) in Brazil steel plant reported higher work injury rate among workers aged below 25 years. An international review on non fatal injuries by Salminen (2004) revealed higher work injury rate for young and older workers. The study also concluded that young men below 25 years are more prone to injury risk. The young workers have higher non fatal injury rate than the older workers in 56% of the studies. In 17% of studies lower injury rate for young workers were reported and in the remaining 27% of studies, no difference between young and older workers were established. In all these published studies only reported work injuries have been considered for analysis whereas the present study considers NRHFLS work injuries among welders.

Based on the above discussion the following null hypotheses are set to test the age and pain frequencies due to NRHFLS work injury relationship among different age groups of the welder population employed by firms in the EFC, welders employed by OSF firms and USF firms.

For testing the relationship between age and pain frequencies, welders age is classified into three age groups $A_1$ (< 25 years), $A_2$ (26-35 years) and $A_3$ (> 35 years). The following null hypotheses are set in the following sections to test the above relationship.

**$H0_{4\text{-}4}$**: There is no significant influence of age groups on pain frequencies due to NRHFLS work injuries among the welder population employed by firms in EFC.

**$H0_{4\text{-}5}$**: There is no significant influence of age groups on pain frequencies due to NRHFLS work injuries among the welders employed by OSF firms.

**$H0_{4\text{-}6}$**: There is no significant influence of age groups on pain frequencies due to NRHFLS work injuries among the welders employed by USF firms.

For testing the advanced hypotheses, one way ANOVA is performed and the results of the test are shown in Table 4.13.

The Table 4.12 shows the means and standard deviations of pain frequencies due to NRHFLS work injuries of the welder population and different sectors.

**Table 4.12** Mean and standard deviation of $A_1$ $A_2$ and $A_3$ age groups employed by firms in EFC, OSF and OSF firms

| Age | Pain frequencies due to NRHFLS Work injuries | | |
|---|---|---|---|
| | n | M | SD |
| **Welder population in EFC** | | | |
| A1 < 25 years | 296 | 4.62 | 1.78 |
| A2 = 26 -35 years | 500 | 5.15 | 2.10 |
| A3 > 35 years | 279 | 4.13 | 1.93 |
| **Welders employed by OSF firms** | | | |
| A1 < 25 years | 219 | 3.93 | 1.13 |
| A2 = 26 -35 years | 285 | 3.83 | 1.16 |
| A3 > 35 years | 188 | 3.82 | 1.10 |
| **Welders employed by USF firms** | | | |
| A1 < 25 years | 77 | 6.55 | 1.89 |
| A2 = 26 -35 years | 215 | 6.93 | 1.74 |
| A3 > 35 years | 91 | 6.59 | 1.95 |

**Table 4.13** Influence of age groups on pain frequencies due to NRHFLS work injuries among the welder population employed in EFC, welders employed by OSF and USF firms. Results of one way ANOVA

| | SS | df | MS | F | Sig. |
|---|---|---|---|---|---|
| **Welder population in EFC** | | | | | |
| Between Groups | 64.16 | 2 | 32.08 | 8.20 | .000** |
| Within Groups | 4195.78 | 1072 | 3.91 | | |
| Total | 4259.94 | 1074 | | | |
| **Welder employed by OSF firms** | | | | | |
| Between Groups | 1.648 | 2 | .82 | .64 | .524 |
| Within Groups | 689 | 689 | 1.27 | | |
| Total | 881.403 | 692 | | | |
| **Welder employed by USF firms** | | | | | |
| Between Groups | 12.55 | 2 | 6.27 | 1.87 | .158 |
| Within Groups | 1270.13 | 380 | 3034 | | |
| Total | 1282.68 | 382 | | | |

**p < 0.01; *p < 0.05

**Interpretation:**

- The results of ANOVA test in Table 4.13 shows age groups influencing pain frequencies due to NRHFLS work injuries among the welder population employed by the firms in EFC are significant $F(2,1072) = 8.20$, $p < 0.01$. Hence, null hypothesis $H0_{4\text{-}4}$ is rejected and alternate hypothesis proposing the influence of age groups on pain frequencies due to NRHFLS work injuries is accepted at 0.01 significance level.
- The results of ANOVA test in Table 4.13 shows influence of age groups on pain frequencies due to NRHFLS work injuries among the welders employed by OSF firms in EFC is not significant $F(2, 689) = 0.64$, $p > 0.01$. Hence, the results supports null hypothesis $H0_{4\text{-}5}$ which proposes no influence of age on pain frequencies due to NRHFLS work injuries.

- The results of ANOVA test in Table 4.13 shows age group influencing pain frequencies due to NRHFLS work injuries among the welders employed by OSF firms is not significant $F(2, 689) = 1.87$, $p > 0.01$. Hence, the results supports null hypothesis $H0_{4-6}$ which proposes no influence of age on influencing pain frequencies due to NRHFLS work injuries.

The results of ANOVA test indicate that influence of age groups on pain frequencies due to NRHFLS work injuries is significant among the welder population employed by firms in EFC. However, the influence of age on work are not significant among the welders employed by OSF and USF firms.

## 4.6 PERSONAL ATTRIBUTE: IMPACT OF EXPERIENCE ON PAIN FREQUENCIES DUE TO NRHFLS WORK INJURIES AMONG WELDERS EMPLOYED IN EFC, OSF AND USF FIRMS

Experience represents the amount of time a welder is employed in the job. General belief is that an experienced welder perceives his job more precisely than an inexperienced welder. Comparatively an experienced welder who is exposed to hazardous environment for an extended time has higher likelihood of meeting with work injuries. There exists a significant relationship between work experience and work injury risk (Cooper and Philip 2004). Studies on mine workers (Maiti and Bhattacherjee, 1999) and steel plant workers (Basha, 2012) reported no relationship between work experience and work injury. A belief is that an experienced welder will have more control as they are familiar with the hazards present in the fabrication environment and knows how to avoid hazardous situation than a lesser experienced welder. In tune with the above discussed facts, the following null hypotheses are set to test the relation between welder experience and pain frequencies due to NRHFLS work injuries

**$H0_{4\text{-}7}$:** There is no significant influence of welder experience on pain frequencies due to NRHFLS work injuries among welders employed by firms in EFC.

**$H0_{4\text{-}8}$:** There is no significant influence of welder experience on pain frequencies due to NRHFLS work injuries among welders employed by OSF firms.

**$H0_{4\text{-}9}$:** There is no significant influence of welder experience on pain frequencies due to NRHFLS work injuries among welders employed by USF firms.

For testing the influence of welder experience on pain frequencies due to NRHFLS work injuries welder experience is categorized into three groups among the welder population employed in EFC $E_1$ (1- 10 years), $E_2$ (11 - 20 years) and $E_3$ (21 - 30 years).

For testing the hypotheses, one way ANOVA test is performed. The results are shown in Table 4.15.

The Table 4.14 shows the means and standard deviations of pain frequencies due to NRHFLS work injuries of the welder population and different sectors.

**Table 4.14** Mean and standard deviation of $E_1$ $E_2$ and $E_3$ welder experience groups employed by firms in EFC, OSF and OSF firms

| Age | Pain frequencies due to NRHFLS Work injuries | | |
|---|---|---|---|
| | n | M | SD |
| **Welder population in EFC** | | | |
| $E_1$ 1-10 years | 306 | 4.98 | 1.99 |
| $E_2$ 11 - 20 years | 481 | 4.95 | 2.04 |
| $E_3$ 21 - 30 years | 288 | 4.70 | 1.87 |
| **Welders employed by OSF firms** | | | |
| E1: 1-10 years | 188 | 3.82 | 1.10 |
| E2: 11 - 20 years | 285 | 3.83 | 1.16 |
| E3: 21 - 30 years | 219 | 3.86 | 1.30 |
| **Welders employed by USF firms** | | | |
| E1: 1-10 years | 118 | 6.82 | 1.79 |
| E2: 11 - 20 years | 196 | 6.69 | 1.91 |
| E3: 21 - 30 years | 69 | 6.94 | 1.67 |

**Table 4.15** Influence of experience groups on pain frequencies due to NRHFLS work injuries among the welder population employed in EFC, welders employed by OSF and USF firms. Results of one way ANOVA

| | SS | df | MS | F | Sig. |
|---|---|---|---|---|---|
| **Welder population in EFC** | | | | | |
| Between Groups | 13.27 | 2 | 6.63 | 1.67 | .188 |
| Within Groups | 4246.67 | 1072 | 3.96 | | |
| Total | 4259.94 | 1074 | | | |
| **Welder employed by OSF firms** | | | | | |
| Between Groups | 1.64 | 2 | .82 | .82 | .510 |
| Within Groups | 879.75 | 689 | 1.27 | | |
| Total | 881.40 | 691 | | | |
| **Welder employed by USF firms** | | | | | |
| Between Groups | 3.64 | 2 | 1.82 | .54 | .583 |
| Within Groups | 1279.04 | 380 | 3.36 | | |
| Total | 1282.68 | 382 | | | |

**p < 0.01; *p < 0.05

**Interpretation:**

- The results of ANOVA test in Table 4.15 shows influence of experience groups on pain frequencies due to NRHFLS work injuries among the welders population employed in EFC is not significant $F(2, 1072) = 1.67$, $p > 0.01$. Hence, the results supports the null hypothesis $H0_{4\text{-}7}$ which proposes no influence of welder experience on pain frequencies due to NRHFLS work injuries.
- The results of ANOVA test in Table 4.15 shows influence of experience groups on pain frequencies due to NRHFLS work injuries among the welders employed by OSF firms is not significant $F(2, 689) = 0.82$, $p > 0.01$. Hence, the result supports the null hypothesis $H0_{4\text{-}8}$ which proposes

no influence of welder experience on pain frequencies due to NRHFLS work injuries.

- The results of ANOVA test in Table 4.15 shows influence of experience group on pain frequencies due to NRHFLS work injuries among the welders employed by USF firms is not significant $F(2, 380) = 0.54$, $p > 0.01$. Hence, the result supports the null hypothesis $H0_{4\text{-}9}$ which proposes no influence of welder experience on pain frequencies due to NRHFLS work injuries.

Hence it is shown that welder experience has no influence on pain frequencies due to NRHFLS work injuries among the welder population employed in EFC and welders employed by both OSF and USF firms.

## 4.7 EMPLOYMENT FACTORS INFLUENCING NRHFLS WORK INJURIES

Some of the common factors related to employment found to be associated with work injuries risk by the researchers are, extended working hours (Salminen, 2004), shift work (Levin et al., 1985; Frank, 2000), and occupation (Leigh et al., 1990; Maiti and Bhattacherjee, 1999, Maiti et al., 2001).

Growth of precarious employment in developing countries is a concern due to seasonal demand in customer orders, which peak and subside over times. Adhoc form of recruitment is convenient for firms in developing countries to offset the cost in holding the personnel on permanent basis. A review on precarious employment characterizes the work injury risk factors of precarious employment forms as extended working hours, shift work, adhoc nature of employment, on-the-job-training methods which that lacks safety training, higher unregulated physical workload, non compliance of safety device and loading of worker beyond their limits have been reported as factors influencing work injuries (Quinlan et al., 2001). Field visits, consultations with welders employed in EFC and examination of reports of CSR perceptions and activities of small and medium enterprises (SMES) survey report, (2008) reveal that the welder population in EFC is similar to that of precarious employment forms described by Quinlan et al. (2001). The welder population employed in EFC (See section 4.2) can be described as similar to precarious in nature, as the major portion of the welder population employed is of adhoc nature, trained on the job and having extended working hours, shift work and unregulated physical work load.

A review by Costa (1996) opined that majority of the studies revealed work injuries occurred in night shift. A review by Ducheon and Smith (1993) put forth that extended working hours increased the number of work injuries. Investigation by Vegso, et al. (1996) on manufacturing sector workers concludes on higher frequency of work injuries during extended working hours that are not reported. A study by Martin et al. (2007) revealed that needle stick injuries are prevalent among trainee surgeons, which are not generally reported. The study also revealed that certain types of less severity work injuries are not reported and most of these injuries are treated with first aid and accepted as inherent part of the work characteristic.

The employment factors considered in this study are

- Working hours;
- Shift work;
- Nature of employment;
- Mode of apprenticeship training;
- Physical workload.

### 4.7.1 Influence of working hours on pain frequencies due to NRHFLS work injuries among welders employed in OSF and USF firms.

Based on the facts discussed in (See Sec 4.7), the following null hypotheses are set to find the influence of working hours on pain frequencies due to NRHFLS work injuries among the welder population employed in EFC and welder employed in OSF and USF firms.

**$H0_{4\text{-}9}$:** There is no significant influence of working hours on mean pain frequencies due to NRHFLS work injuries among welder population employed by firms in EFC.

**$H0_{4\text{-}10}$:** There is no significant influence of working hours on mean pain frequencies due to NRHFLS work injuries among welders employed by OSF firms.

To test the null hypotheses independent sample t test was performed and results are shown in Table 4.16.

**Table 4.16** Influence of working hours on mean pain frequencies due to NRHFLS work injuries among welder population employed in EFC and welders employed in OSF and USF firms. Results of independent sample t test

| Variable | Mean | SD | $t^{\#}$ | $df^{\#}$ | p |
|---|---|---|---|---|---|
| Working hours -Welder population employed by firms in EFC | | | $-15.29^{\#}$ | $1013^{\#}$ | .000** |
| = 8 hours | 3.99 | 1.31 | | | |
| > 8 hours+ | 5.62 | 2.14 | | | |
| Working hours - Welders employed by OSF firms | | | -.106 | 690 | .915 |
| = 8 hours | 3.86 | 1.12 | | | |
| > 8 hours+ | 3.87 | 1.14 | | | |

The #t and #df were adjusted because the variance were not equal; **$p < 0.01$; *$p < 0.05$; +greater than 8 hours work was not applicable among welders employed by USF firms as the response was less than 10 %.

- The results in Table 4.16 shows that on an average, welders engaged in more than eight hours work (M = 5.62, SD = 2.14) experience higher pain frequencies due to NRHFS work injuries than welders engaged in eight hours work (M = 3.99, SD = 1.31) among welder population employed in EFC. The difference is significant $t(1013) = -15.29$, $p < 0.01$, d = .91. Hence the null hypothesis $H0_{4-9}$ is rejected and alternate hypothesis proposing the difference is accepted at 0.01 level of significance.

  The value of effect size'd' indicates a large magnitude of difference between levels of working hours for influence on pain frequencies due to NRHFLS work injuries among welder population employed in EFC. A large effect size (Cohen, 1988) can be of practical importance to be considered for intervention initiatives among the welder population employed in EFC.

- The results in Table 4.16 shows that on an average, welders engaged in more than eight hours work (M = 3.87 SD = 1.14) experience higher pain frequencies due to NRHFS work injuries than welders employed in eight hours work (M = 3.86, SD = 1.12) among the welders employed by OSF firms. This difference is not significant $t(690) = -0.10$, $p > 0.01$. Hence the results supports the null hypothesis $H0_{4-10}$ proposing no significant influence of working hours on mean pain frequencies due to NRHFLS work injuries among welders employed by OSF firms.

  The influence of working hours on pain frequencies due to NRHFLS work injuries is significant for welder population employed by the firms in EFC. However, the result is not significant for welders employed by OSF firms.

### 4.7.2 Influence of shift work on pain frequencies due to NRHFLS work injuries among welders employed in EFC

Based on the facts discussed in (See Sec 4.7), the following null hypothesis is advanced to find the influence of shift work on pain frequencies due to NRHFLS work injuries among the welder population employed in EFC.

**$H0_{4\text{-}11}$:** There is no significant influence of shift work on pain frequencies due to NRHFLS work injuries among the welder population employed by firms in EFC.

To test the null hypothesis independent sample t test was performed and results are shown in Table 4.17.

**Table 4.17** Influence of shift work on pain frequencies due to NRHFLS work injuries among the welder population employed in EFC. Result of independent sample t test

| Variable: | Mean | SD | $t^{\#}$ | $df^{\#}$ | p |
|---|---|---|---|---|---|
| | | | $28.30^{\#}$ | $564^{\#}$ | .000** |
| Shift work$^{+}$ | 6.78 | 1.83 | | | |
| Non shift work (general shift) | 3.86 | 1.12 | | | |

The $^{\#}$t and $^{\#}$df were adjusted because the variance were not equal; **p < 0.01; *p < 0.05; $^{+}$shift work is not prevalent among welders employed by USF firms.

**Interpretation**

- The results in Table 4.17 shows that on an average, welders engaged in shift work experiences higher pain frequencies due to NRHFS work injuries (M = 6.78, SD = 1.83) than welders employed in no shift work (M = 3.86, SD = 1.12). This difference is significant $t(564) = 28.30$, $p < 0.01$, $d = 1.43$. Hence the null hypothesis $H0_{4\text{-}11}$ is rejected, alternate hypothesis proposing the difference is accepted at 0.01 level of significance.

The value of effect size 'd' indicates a large magnitude of difference between welders working in shift work and non shift work for the influence on pain frequencies due to NRHFLS work injuries among welder population employed in EFC. A large effect size (Cohen, 1988) greater than one can be of practical importance to be considered for intervention initiatives among the welder population employed in EFC.

Therefore it can be concluded that shift work significantly influences pain frequencies due to NRHFLS work injuries among welder population employed in EFC.

### 4.7.3 Influence of nature of employment on pain frequencies due to NRHFLS work injuries welders employed in EFC and welders employed by OSF firms.

Based on the facts discussed in (See Sec 4.7), the following null hypothesis is advanced to find the influence of nature of employment on pain frequencies due to NRHFLS work injuries among the welder population employed in EFC.

**$H0_{4\text{-}12}$:** There is no significant influence of nature of employment on pain frequencies due to NRHFLS work injuries among the welder population employed by firms in EFC.

**$H0_{4\text{-}13}$:** There is no significant influence of nature of employment on pain frequencies due to NRHFLS work injuries among the welders employed by OSF firms.

To test the null hypotheses independent sample t test was performed and results are shown in Table 4.18.

**Table 4.18** Influence of nature of employment on pain frequencies due to NRHFLS work injuries among the welder population employed in EFC and welders employed by OSF firms. Result of independent sample t test

| Variable | Mean | SD | t# | df# | p |
|---|---|---|---|---|---|
| Nature of employment-Welder population in EFC | | | -10.81# | 768# | .000** |
| Regular | 4.03 | 1.25 | | | |
| Adhoc/Contract | 5.19 | 2.10 | | | |
| Nature of employment-Welder employed by OSF firms+ | | | -1.75 | 690 | .080 |
| Regular | 3.80 | 1.08 | | | |
| Adhoc/Contract | 3.96 | 1.21 | | | |

The t# and df# were adjusted because the variance were not equal; **p < 0.01; *p < 0.05; +less than ten percent of welders were recruited on regular rolls by USF firms.

**Interpretation**

- The results in Table 4.18 shows that on an average, welders recruited through adhoc/contract rolls (M = 5.19, SD = 2.10) experiences higher pain frequency due to NRHFS work injuries than welders recruited through regular rolls (M = 4.03, SD = 1.25) in EFC. This difference is significant t(768) = -10.81, p < 0.01, d = 0.67. Hence, the null hypothesis $H0_{4\text{-}12}$ is rejected alternate hypothesis proposing the difference is accepted at p < 0.01.

  The value of effect size'd' indicates a medium magnitude of difference between welders recruited on adhoc/contract rolls basis and regular rolls for their influence on pain frequencies due to NRHFLS work injuries among welder population employed in EFC. Though a medium effect size of d = 0.67 (Cohen, 1988) can be of practical importance to be considered for intervention initiatives among the welder population employed in EFC.

- The results in Table 4.18 shows that on an average, welders recruited through adhoc employment ($M = 3.96$, $SD = 1.12$) experiences higher pain frequencies due to NRHFS work injuries than welders employed in regular rolls ($M = 3.80$, $SD = 1.08$) in OSF firms. This difference is not significant $t(690) = -1.75$, $p > 0.01$. Hence the results supports null hypothesis $H0_{4\text{-}13}$ proposing no significant influence of nature of employment on pain frequencies due to NRHFLS work injuries among the welders employed by OSF firms.

The influence of nature of employment on pain frequencies due to NRHFLS work injuries is significant for the welder population employed by the firms in EFC. However, the result is not significant for welders employed by OSF firms.

### 4.7.4 Influence of mode of apprenticeship training on pain frequencies due to NRHFLS work injuries among welders employed in EFC and welders employed by OSF firms

Based on the facts discussed in (See Sec 4.7), the following null hypothesis is set to find the influence of mode of apprenticeship training on pain frequencies due to NRHFLS work injuries among the welder population employed in EFC.

**$H0_{4\text{-}14}$:** There is no significant influence of mode of apprenticeship training on pain frequencies due to NRHFLS work injuries among the welder population employed by firms in EFC.

**$H0_{4\text{-}15}$:** There is no significant influence of mode of apprenticeship training on pain frequencies due to NRHFLS work injuries among the welders employed by OSF firms.

To test the null hypotheses independent sample t test was performed and results are shown in Table 4.19.

**Table 4.19** Influence of mode of apprenticeship training on pain frequencies due to NRHFLS work injuries among the welder population employed by firms in EFC and welders employed by OSF firms. Results of independent sample t test

| Variable | Mean | SD | $t^{\#}$ | $df^{\#}$ | p |
|---|---|---|---|---|---|
| Mode of apprenticeship training-Welder population in EFC | | | $-14.55^{\#}$ | $1054^{\#}$ | .000** |
| Institutional-ITI welder trade certificate | 3.91 | 1.17 | | | |
| On-the- job- training-method | 5.38 | 2.12 | | | |
| Mode of apprenticeship training--Welder employed by OSF firms$^{+}$ | | | -.178 | 690 | .859 |
| Institutional-ITI welder trade certificate | 3.85 | 1.10 | | | |
| On-the- job- training-method | 3.87 | 1.20 | | | |

The $t^{\#}$ and $df^{\#}$ were adjusted because the variance were not equal; *p < 0.01; **p < 0.05 significance level; $^{+}$less than ten percent of welders employed in USF firms have acquired welder trade knowledge through institution training.

**Interpretation**

- The results in Table 4.19 shows that on an average, welders who had acquired trade knowledge through on-the-job training (M = 5.38, SD = 2.12) experiences higher pain frequencies due to NRHFS work injuries than welders who had acquired through institutional training (M=3.91, SD = 1.17). This difference is significant t(1054) = -14.55, p < 0.01, d = 0.64 among welders employed in EFC. Hence the null hypothesis $H0_{4-14}$ is rejected and alternate hypothesis is proposing the difference is accepted at p<0.01.

The value of effect size'd' indicates a medium magnitude of difference between welders who had acquired the trade knowledge through institutional training and on-the-job-training methods for their influence on pain frequencies due to NRHFLS work injuries among welder population employed in EFC. A medium effect size d = 0.64

(Cohen, 1988) can be of practical importance to be considered for intervention initiatives among the welder population employed in EFC.

- The results in Table 4.19 shows that on an average, welders who had acquired trade knowledge through on-the-job training (M = 3.87, SD = 1.20) experiences higher pain frequencies due to NRHFS work injuries than welders who had acquired through institutional training (M=3.85, SD=1.10). This difference is not significant $t(690) = -0.178$, $p > 0.01$. Hence, the result supports the null hypothesis proposing no significant influence of mode of apprenticeship training on pain frequencies due to NRHFLS work injuries among welders employed by OSF firms.

Mode of apprenticeship training as factor significantly influences pain frequencies due to NRHFLS work injuries among the welder population employed in the EFC. The results are not significant for the welders employed by the OSF firms.

### 4.7.5 Influence of physical workload on pain frequencies due to NRHFLS work injuries among welders employed in EFC and welders employed by OSF and USF firms.

Based on the facts discussed in (See Sec 4.7), the following null hypothesis is set to find the influence of physical workload on pain frequencies due to NRHFLS work injuries among the welder population employed in EFC.

**$H0_{4\text{-}16}$:** There is no significant influence of physical workload on pain frequencies due to NRHFLS work injuries among welder population employed firms in EFC.

**$H0_{4\text{-}17}$:** There is no significant influence of physical workload on pain frequencies due to NRHFLS work injuries among the welders employed by OSF firms.

**H0$_{4\text{-}18}$:** There is no significant influence of physical workload on pain frequencies due to NRHFLS work injuries among the welders employed by USF firms.

To test the null hypotheses independent sample't' test was performed and results are shown in Table 4.20.

**Table 4.20** Influence of physical workload on pain frequencies due to NRHFLS work injuries among the welder population employed by firms in EFC and welders employed by OSF and USF firms. Results of independent sample t test

| Variable | Mean | SD | $t^{\#}$ | $df^{\#}$ | p |
|---|---|---|---|---|---|
| Mean physical workload – EFC population | | | $23.04^{\#}$ | $670^{\#}$ | .000** |
| < 3.3 Kgs Low | 6.32 | 2.01 | | | |
| > 3.3 Kgs High | 3.88 | 1.88 | | | |
| Mean physical workload- OSF firms | | | .636 | 690 | .525 |
| < 4.76 Kgs Low | 3.97 | 1.18 | | | |
| > 4.76 Kgs High | 3.89 | 1.97 | | | |
| Mean physical workload - USF firms | | | $8.01^{\#}$ | $154^{\#}$ | .000** |
| < .77 Kgs Low | 1.13 | .95 | | | |
| > .77 Kgs High | 0.51 | .09 | | | |

**p < 0.01; *p < 0.05; $^{\#}$t and $^{\#}$df were adjusted because the variance were not equal

- The results in Table 4.20 shows that on an average, welders who had executed low physical workload (M = 6.32, SD = 2.01) experiences higher pain frequencies due to NRHFS work injuries than welders who executed higher physical workload (M = 3.88, SD = 1.88). This difference is significant t(670) = 23.04, p < 0.01, d = 0.55. Hence, the null hypothesis H0$_{4\text{-}16}$ is rejected and alternate hypothesis proposing the difference is accepted at p < 0.01.

  The value of effect size'd' indicates a medium magnitude of difference between welders who executed lower physical workload and higher physical on pain frequencies due to NRHFLS work injuries among welder population employed in EFC. A medium effect size of d = 0.55 (Cohen, 1988) can be of practical importance to be considered for intervention initiatives among the welder population employed in EFC.

- The results in Table 4.20 shows that on an average, welders who had executed low physical workload (M = 3.97, SD = 1.18) experiences higher pain frequencies due to NRHFS work injuries than welders who executed higher physical workload (M = 3.89, SD = 1.97) in OSF firms. This difference is not significant $t(690) = 0.63$, $p > 0.01$. Hence, the result supports the null hypothesis $H0_{4\text{-}17}$ proposing no significant influence of physical workload on pain frequencies due to NRHFLS work injuries among the welders employed by OSF firms.
- The results in Table 4.20 shows that on an average, welders who had executed low physical workload (M = 1.13, SD = 1.18) experiences higher pain frequencies due to NRHFS work injuries than welders who executed higher physical workload (M = 0.51, SD = 0.09) in USF firms. This difference is significant $t(154) = 8.01$, $p < 0.01$, d=2.24. Hence, the null hypothesis $H0_{4\text{-}18}$ is rejected and alternate hypothesis proposing the difference is accepted at $p < 0.01$.

The value of effect size ‘d’ indicates a very large magnitude of difference between welders who executed lower physical workload and higher physical workload on pain frequencies due to NRHFLS work injuries among welder population employed in EFC. A very large effect size of d = 2.24 (Cohen, 1988) can be of practical importance to be considered for intervention initiatives among the welder population employed in EFC.

Lower physical workload significantly influences pain frequencies due to NRHFLS work injuries among welder population employed by firms in EFC and welders employed by USF firms. The result is not significant among welders employed by OSF firms.

## 4.8 SUMMARY OF FINDINGS AND DISCUSSION

Descriptive analysis was carried out in the data by comparing the welder population employed by firms the engineering fabrication cluster and welders employed in organised and unorganised sector fabrication firms.

**Table 4.21** Summary of descriptive statistics

| Variables | | OSF | USF | EFC population |
|---|---|---|---|---|
| Sector wise sample distribution | | 64.4% (n = 692) | 35.6% (n = 383) | 100% (N = 1075) |
| Nature of employment | Regular | 37.3% (n = 258) | 2.3% (n = 9) | 24.8% (n = 267) |
| | Adhoc/Contract | 62.7% (n = 434) | 97.7% (n = 374) | 75.2% (n = 808) |
| Mode of trade knowledge acquired through | Institution trained | 49.9F% (n = 345) | 1.4% (n = 5) | 32.6%(n = 350) |
| | On-the-job-training | 50.1% (n = 347) | 98.6% (n = 378) | 67.4% (n = 725) |
| Working hours | < 8 hours | 35% (n = 239) | 94% (n = 360) | 55% (599) |
| | > 8 hours | 65% (n = 453) | 6% (n = 23) | 45% (476) |
| Shift work | Yes | 100% (n = 692) | -- | 64.4%(n = 692) |
| | No | -- | 100% (n = 383) | 35.6% (n = 383) |
| Mean pain frequencies due to NRHFLS work injuries | | M = 3.86 | M = 6.78 | M = 4.90 |
| | | SD = 1.13 | SD = 1.83 | SD = 1.99 |
| Age | | M = 33.60 | M = 37.30 | M = 34.92 |
| | | SD = 11.15 | SD =11.31 | SD = 11.77 |
| Experience as welder | | M = 12.20 | M = 10.98 | M = 11.77 |
| | | SD = 8.29 | SD = 7.60 | SD = 8.07 |
| Physical workload | | M = 4.76 | M = 0 .77 | M = 3.34 |
| | | SD = 1.46 | SD = 0.68 | SD = 2.28 |

Descriptive analysis Table 4.21 revealed majority of the welder respondents in the collected data were employed in organized sector fabrication firms (64.40%). Welders employed in organised sector fabrication firms experienced low mean pain frequency (4-frequencies) due to non-reported highly frequent less severe work injuries. Lower mean age (33.60 years) and higher total experience (12.20 years) as welder was associated this sector. While all the welders worked in shifts (100%), worked in extended working hours (65%), welders (50%) had acquired welder trade knowledge through institutional training and a substantial portion of welders were recruited through regular employment (37.30%) in comparison with the welder population employed in EFC.

The welders employed by unorganised fabrication firms experiences higher pain frequency due to non reported highly frequent less severe work injuries (6-frequencies). Higher mean age (37.30 years) and lower welder experience (10.78 years) is associated with this sector. Lower physical workload (.77 Kg), employment in regular working hours (94%), higher proportion of adhoc recruitment (97%), and majority of the welders had acquired the trade knowledge through on-the-job training methods (99%) in comparison with the welder population employed in EFC.

Personal attributes and employment factors identified from the literature was tested for their influence on pain frequencies due to NRHFLS work injuries among welder employed in the population and its different sectors. The results are summarized in Table 4.22.

**Table 4.22** Summary of findings with respect to hypothesis set to test their association with pain frequencies due to NRHFLS work injuries among welders employed in different sectors in EFC population

| Factors in the Study | | Welder population in EFC | Welders employed by Organised sector firms | Welders employed by Unorganised sector firms | Remarks |
|---|---|---|---|---|---|
| Pain frequency due to NRHFLS work injuries | | Hypothesized mean | Sig *(Sec 4.3)* | Sig *(Sec 4.3)* | For intervention initiatives |
| | | | Between OSF and USF firms – Sig *(Sec 4.4)* | | For intervention initiatives |
| Personal attributes | Age | Sig *(Sec 4.5)* | Non-sig *(Sec 4.5)* | Non-sig *(Sec 4.5)* | For intervention initiatives |
| | Experience | Non-sig *(Sec 4.6)* | Non-sig *(Sec 4.6)* | Non-sig *(Sec 4.6)* | – |
| Employment Factors | Working Hours | Sig *(Sec 4.7.1)* **d = .91** | Non-sig *(Sec 4.7.1)* | -- | For intervention initiatives |
| | Shift-Work | Sig *(Sec 4.7.2)* **d = 1.43** | -- | -- | - For intervention initiatives - |
| | Nature of Employment | Sig *(Sec 4.7.3)* **d = .64** | Non-sig *(Sec 4.7.3)* | -- | For intervention initiatives -- |
| | Mode of Apprenticeship Training | Sig *(Sec 4.7.4)* **d= 1.83** | Non-sig *(Sec 4.7.4)* | -- | - For intervention initiatives - |
| | Physical Workload | Sig *(Sec 4.7.5)* **d = .55** | Non-Sig *(Sec 4.7.5)* | Sig *(Sec 4.7.5)* **d = 2.24** | For intervention initiatives |

Sig – Significant; Non-sig - Not Significant

**Interpretation of Table 4.22 findings**

- The mean pain frequencies due to NRHFLS work injuries are different between welder population and welders employed by organised and unorganised sector fabrication firms.
- The mean pain frequencies due to NRHFLS work injuries are different between welders employed by organised and unorganised sector fabrication firms.
- Age significantly influences pain frequencies due to NRHFLS work injuries among welder population employed in EFC. The result contradicts the findings of no relation between age and work injury (Maiti and Bhattacherjee 1999; Breslin et al., 2007).
- Middle age group of welders are associated with higher mean frequencies due to NRHFLS work injuries. This finding contradicts the review findings of Salminen (2004) that young workers below 25 years are more likely to be injured during work.
- The age influencing pain frequencies due to NRHFLS work injuries are significant among the welder population employed in EFC. But, when the sample is split into organised and unorganised group the age is not found to influence pain frequencies due to NRHFLS work injuries in both groups. This finding supports the inconclusiveness of age and work injury relationship findings by Khanzode et al. (2012) and Salminen (2004).
- Welder experience do not significantly influence pain frequencies due to NRHFLS work injuries among the welder population, welders employed by OSF and USF firms.
- Working hours do not significantly influence pain frequencies due to NRHFLS work injuries. The results indicate welders engaged in

extended working hours experience more pain frequencies due to NRHFLS work injuries. This finding is in tune with increased work injury risk during extend working hours (Ducheon and Smith, 1993; Vegso et al., 1996). The influence is significant for the welder population and insignificant for the welders employed by organised sector firms in EFC. The findings indicate an inconclusiveness of increased work injury risk among welders employed in extended working hours.

- Shift work significantly influences pain frequencies due to NRHFLS work injuries among welders in EFC population and is in tune with the literature findings of increased work injury risk Salminen (2004) due to shift work.
- Nature of employment influences pain frequencies due to NRHFLS work injuries. The results indicate adhoc/contract nature of employment is associated with higher pain frequencies due to NRHFLS work injuries among welder population employed by firms in EFC. The finding is in tune with findings of precarious employment charteristic which reveals that adhoc/contract nature of employed workers forgoes basic safety training among workers responsible for causing work injuries (Saha et al., 2005; Quinlan et al., 2001). However, the influence of nature of employment on work injuries is not significant for welders employed by OSF firms that indicate an inconclusive relation between nature of employment and pain frequencies due to NRHFLS work injuries.
- Mode of apprenticeship training influences pain frequencies due to NRHFLS work injuries. Welders who had acquired trade knowledge through on-the-job-training methods experience more pain frequencies due to NRHFLS work injuries which is in tune with findings of Ganesh and Priya (2014) of increased work injuries among welders due to lack of institutional training. In addition, the finding is in tune with the observation

of Quinlan et al. (2001) in his study of general workers that lack of institutional training exposes workers to higher work injury risk. The influence is found significant for the welder population in EFC and insignificant for welders employed by OSF firms, which shows inconclusiveness in mode of apprenticeship training and work injury relationship.

- Welders who executed low mean physical workload experience more pain frequencies due to NRHFLS work injuries. This association is significant among welder population and welders employed by unorganised sector fabrication firms. However, the association result is not significant among the welders employed by organised sector firms. This finding contradicts the finding of higher physical workload (Josephine et al. 2001) as cause of work injuries. This significant finding can be used for initiating intervention initiatives to mitigate pain frequencies due to non reported highly frequent less severe work injuries among welders.
- Lower mean physical workload is significant in influencing pain frequencies due to non reported highly frequent less severe work injuries among welder population.
- The interventions initiatives can be prioritized and targeted on specific factors based on the effect size that shows the magnitude of difference between employment factor levels with respect to pain frequencies due to NRHFLS work injuries Table 4.22 as interpreted below
  - Lower physical workload is significant for the welder population (d =.55) and welders (d = 2.25) employed by organised sector fabrication firms;
  - Mode of apprenticeship training (d = 1.83);
  - Shift work (d=1.43);

- Working hours (d=0.91);
- Nature of employment (d=0.64).

Above discussed factors can be prioritized by considering the magnitude of effect size greater than one and targeted for intervention initiatives to mitigate NRHFLS work injuries among welders employed in the engineering fabrication cluster.

Chapter 5

# MODELING THE INFLUENCE OF WORK FACTOR DOMAINS ON PAIN FREQUENCIES DUE TO NON REPORTED HIGHLY FREQUENT LESS SEVERE WORK INJURIES AMONG WELDERS

Contents



## 5.1 WORK FACTOR DOMAINS IN FABRICATION ENVIRONMENT

The objective of this chapter is to identify dominant work factor domains that influence pain frequencies due to NRHFLS work injuries

- To identify the dominant work factor domains that influences pain frequencies due to NRHFLS work injuries among the welder population employed by firms in the engineering fabrication cluster.
- To identify the dominant work factor domains that influences pain frequencies due to NRHFLS work injuries among the welders employed by organised sector fabrication firms.
- To identify the dominant work factor domains that influences pain frequencies due to NRHFLS work injuries among the welders employed by unorganised sector fabrication firms.

The eight work factor domains and their characteristic items (See section 3.4.4) identified for industrial fabrication environment are: Health Perception (HP), Safety Culture (SC), Physical Task Content (PTC), Metal Task Content (MTC), Physical Environment (PE), Social Environment (SE), Technical Environment (TE) and Perceived Benefit (PB).

These work factor domains interact in the form of energy interactions with the welders present in the fabrication work environment. At certain instances due to inadequacies in resources, control over energy interactions is lost in the work factor domain that leads to pain frequencies due to NRHFLS work injuries. As the study is of exploratory nature, to identify the work factor domains that influences pain frequencies due to NRHFLS work injuries among the welder population stepwise wise regressions method is performed (Wright, 1997, p.81). In the following sections, hypotheses are advanced to identify the work factor domains that influence pain frequencies due to NRHFLS work injuries among the welder population and welders employed by organised and unorganised sector fabrication firms.

## 5.2 INFLUENCE OF WORK FACTOR DOMAINS ON PAIN FREQUENCIES DUE TO NON REPORTED HIGHLY FREQUENT LESS SEVERE WORK INJURIES AMONG THE WELDERS EMPLOYED BY FIRMS IN ENGINEERING FABRICATION CLUSTER

Based on the above discussion (See sec 5.1) the following null hypothesis is advanced to identify the influential work factor domains that cause pain frequencies due to NRHFLS work injuries among welder population.

**$H0_{5\text{-}1}$:** There is no significant influence of work factor domains in causing pain frequencies due to NRHFLS work injuries among the welder population.

To test the null hypothesis $H0_{5\text{-}1}$ stepwise multiple regression analysis is performed with mean scores of the work factor domains. The descriptive statistics of the measures and correlation coefficients of work factor domains and pain frequencies are presented in Table 5.1. The results of the regression analysis are shown in Tables 5.2 and 5.3.

**Table 5.1** Descriptive statistics of work factor domains predicting pain frequencies due to NRHFLS work injuries for welder population (N= 1075)

| Variable | Zero order correlation | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **HP** | **SC** | **PTC** | **MTC** | **PE** | **SE** | **TE** | **PB** | **NRHFLS work injuries** |
| HP | | -.17** | -.17** | .14** | 0.4 | -.21** | 0.6 | -.12** | .38** |
| SC | | | .53** | .21** | .45** | .55** | .23** | .30** | -.45** |
| PTC | | | | .19** | .39** | .47** | .20** | .29** | -.37** |
| MTC | | | | | .14** | .15** | 0.8 | .10* | .09 |
| PE | | | | | | .36** | .15** | .23** | -.32** |
| SE | | | | | | | .18** | .28** | -.44** |
| TE | | | | | | | | .10* | -.15** |
| PB | | | | | | | | | -.24** |
| M | 16.35 | 31.89 | 14.09 | 26.85 | 17.78 | 14.13 | 16.51 | 7.12 | 4.90 |
| SD | 2.42 | 5.13 | 2.74 | 3.05 | 2.81 | 2.84 | 2.36 | 2.04 | 1.99 |

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

**Table 5.2** Model summary of stepwise multiple regression analysis for welder population (N=1075)

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | | | | | Durbin Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | R Square Change | F Change | df1 | df2 | Sig. F Change | |
| 1 | .451[a] | .203 | .202 | 1.779 | .203 | 273.306 | 1 | 1073 | .000** | |
| 2 | .547[b] | .299 | .298 | 1.669 | .096 | 146.503 | 1 | 1072 | .000** | |
| 3 | .577[c] | .333 | .331 | 1.629 | .034 | 55.002 | 1 | 1071 | .000** | |
| 4 | .588[d] | .346 | .343 | 1.614 | .013 | 20.047 | 1 | 1070 | .000** | 1.823 |
| 5 | .592[e] | .350 | .347 | 1.609 | .004 | 8.453 | 1 | 1069 | .004** | |
| 6 | .594[f] | .353 | .350 | 1.606 | .003 | 4.622 | 1 | 1068 | .009** | |

**p < 0.01; *p < 0.05

a. Predictors: (Constant), SC

b. Predictors: (Constant),SC, HP

c. Predictors: (Constant), SC, HP, SE

d. Predictors: (Constant), SC, HP, SE, PE

e. Predictors: (Constant), SC, HP, SE, PE, PB

f. Predictors: (Constant),SC, HP, SE, PE, PB, PTC

**Table 5.3** Results of stepwise regression for welder population (N=1075)

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Correlations | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B | SE | β | | | Zero-order | Partial | Semi Partial | Tolerance | VIF |
| 1[a] | (Constant) | 10.475 | .342 | | 30.661 | .000** | | | | | |
| | SC | -.175 | .011 | -.451 | -16.532 | .000** | -.451 | -.451 | -.451 | 1.000 | 1.000 |
| | $F_{(1,1073)} = 273.306$ $p < 0.01$, $R^2 = 0.203$ | | | | | | | | | | |
| 2[a] | (Constant) | 5.602 | .515 | | 10.886 | .000** | | | | | |
| | SC | -.155 | .010 | -.398 | -15.354 | .000** | -.451 | -.425 | -.393 | .972 | 1.029 |
| | HP | .258 | .021 | .314 | 12.104 | .000** | .380 | .347 | .310 | .972 | 1.029 |
| | $F_{(2,1072)} = 228.435$ $p < 0.01$, $R^2 = 0.299$ | | | | | | | | | | |
| 3[a] | (Constant) | 6.696 | .523 | | 12.794 | .000** | | | | | |
| | SC | -.108 | .012 | -.279 | -9.297 | .000** | -.451 | -.273 | -.232 | .692 | 1.445 |
| | HP | .237 | .021 | .288 | 11.262 | .000** | .380 | .325 | .281 | .954 | 1.049 |
| | SE | -.157 | .021 | -.224 | -7.416 | .000** | -.437 | -.221 | -.185 | .682 | 1.467 |
| | $F_{(3,1071)} = 178.296$ $p <0 .01$, $R^2 = 0.333$ | | | | | | | | | | |
| 4[a] | (Constant) | 7.414 | .543 | | 13.654 | .000** | | | | | |
| | SC | -.091 | .012 | -.234 | -7.448 | .000** | -.451 | -.222 | -.184 | .621 | 1.610 |
| | HP | .242 | .021 | .295 | 11.608 | .000** | .380 | .334 | .287 | .950 | 1.052 |
| | SE | -.142 | .021 | -.202 | -6.662 | .000** | -.437 | -.200 | -.165 | .664 | 1.506 |
| | PE | -.089 | .020 | -.126 | -4.477 | .000** | -.315 | -.136 | -.111 | .779 | 1.284 |
| | $F_{(1,1070)} = 141.112$ $p < 0.01$, $R^2 = 0.346$ | | | | | | | | | | |
| 5[a] | (Constant) | 7.580 | .544 | | 13.931 | .000** | | | | | |
| | SC | -.086 | .012 | -.221 | -6.984 | .000** | -.451 | -.209 | -.172 | .608 | 1.644 |
| | HP | .242 | .021 | .294 | 11.629 | .000** | .380 | .335 | .287 | .950 | 1.052 |
| | SE | -.134 | .021 | -.191 | -6.258 | .000** | -.437 | -.188 | -.154 | .653 | 1.531 |
| | PE | -.084 | .020 | -.118 | -4.199 | .000** | -.315 | -.127 | -.104 | .772 | 1.296 |
| | PB | -.075 | .026 | -.076 | -2.907 | .004** | -.244 | -.089 | -.072 | .883 | 1.132 |
| | $F_{(1,1069)} = 115.366$ $p <0 .01$, $R^2 =0.350$ | | | | | | | | | | |
| 6[a] | (Constant) | 7.751 | .549 | | 14.119 | .000** | | | | | |
| | SC | -.078 | .013 | -.200 | -6.054 | .000** | -.451 | -.182 | -.149 | .556 | 1.799 |
| | HP | .239 | .021 | .290 | 11.453 | .000** | .380 | .331 | .282 | .945 | 1.058 |
| | SE | -.124 | .022 | -.178 | -5.714 | .000** | -.437 | -.172 | -.141 | .627 | 1.594 |
| | PE | -.077 | .020 | -.108 | -3.806 | .000** | -.315 | -.116 | -.094 | .752 | 1.330 |
| | PB | -.068 | .026 | -.070 | -2.638 | .008** | -.244 | -.080 | -.065 | .871 | 1.149 |
| | PTC | -.048 | .022 | -.066 | -2.150 | 009** | -.368 | -.066 | -.053 | .639 | 1.564 |
| | $F_{(1,1068)} = 97.235$ $p < 0.01$, $R^2 =0.353$ | | | | | | | | | | |

[a] dependent variable pain frequencies due to NRHFLS work injuries; **p < 0.01; *p < 0.05

**Interpretation**

The Table 5.1 displays the descriptive information of means, standard deviation and zero-order correlation values between pain frequencies due to NRHFLS work injuries and eight work factors domains. The Table 5.2 shows the model summary and Table 5.3 displays the result of the stepwise multiple regression analysis.

The six ANOVA results reported in Table 5.2 corresponds to six models. The Table 5.3 shows the stepwise regression procedure that adds one variable at a time to the model during the test. Each step results in a model and each successive step modifies the older model and replaces it with a new work factor domain. Each models are tested for its statistical significance. The df1 column in Table 5.2 informs final model built in six steps; each step results in a statistically valid model. Examining the df1 column in Table 5.2 shows that one variable added during each step (the degrees of freedom tracks regression effect, as they are the counts of the number of predictors in the model). In model building, it is deduced that two predictors MTC and TE are excluded that results in six predictors in work factor domains.

In Table 5.2, Model summary presents $R^2$ and Adjusted $R^2$ values for each step along with the amount of R square change. In the first step Table 5.2, footnote refers work factor domain-SC is entered into the Model - 1. The $R^2$ with that predictor in the model is (0.203) which is the square of the multiple correlation coefficient R (0.451) between work factor domain-SC and pain frequencies due to NRHFLS work injuries and is the value of R square change.

On the second step, a positive effect is added to the model by the entry of work factor domain - HP. The $R^2$ with both predictors in the Model 2 is (0.299); the Model 2 gained 0.096 in the value of $R^2$ (0.299 - 0.203 = 0.096) and this reflected in the $R^2$ change for that step.

On the third step, a positive effect is added to the model by the entry of work factor domain – SE. The $R^2$ with three predictors in the model is (0.333); the Model-3 gained 0.034 in the value of $R^2$ (0.333 - 0.299 = 0.034) and this reflected in the $R^2$ change for that step.

On the fourth step, a positive effect added to the model by the entry of work factor domain – PE. The $R^2$ with four predictors in the model is (0.346); the Model-4 gained 0.013 in the value of $R^2$ (0.346 - 0.333 = 0.013) and this reflected in the $R^2$ change for that step.

On the fifth step, a positive effect added to the model by the entry of work factor domain – PB. The $R^2$ with five predictors in the model is (0.350); the Model-5 gained .004 in the value of $R^2$ (0.350 - 0.346 = 0.004) and this reflected in the $R^2$ change for that step.

On the sixth step, a positive effect added to the model by the entry of work factor domain – PTC. The $R^2$ with six predictors in the model is (0.353); the Model-6 gained .003 in the value of $R^2$ (0.353 - 0.350 = 0.003) and this reflected in the $R^2$ change for that step.

Work factor domains mean scores for HP, SC, PTC, MTC, PE, SE, TE and PB were used in stepwise multiple regression analysis to predict pain frequencies due to NRHFLS work injuries. The correlations of the work factor domain variables shown in Table 5.1 indicated all the correlation were statistically significant, except the following correlation relation values between work factor domains HP and TE, HP and PE, MT and TE and MTC and pain frequencies due to NRHFLS work injuries.

The 't' values and its significance level for 'Model-6' in Table 5.3 revealed work factor domains significantly influenced pain frequencies hence null hypothesis $H0_{5-1}$ is rejected and alternate hypothesis proposing the difference at 0.01 level is accepted.

The Model-6 the final step in Table 5.3 shows six work factor domains out of the eight work factor domains. Examining the model for multi-collinearity the largest variation inflation factors is less than 10 (Myers, 1990) and tolerance index is not less than 0.2 (Bower man and O'Connell, 1990). Hence, the selected Model-6 is within reasonable limits for multi collinearity condition. This is further supported by Durbin-Watson value of 1.823 in Table 5.2 that suggests the model is free from reasonable errors. The model is statistically significant, $F_{(1, 1068)} = 97.235$, $p < 0.01$, and approximately accounts for 35% of the variance of pain frequencies due to NRHFLS work injuries ($R^2 = .353$, Adjusted $R^2 = .350$).

Regression equation for Model-6 of work factor domains influencing pain frequencies due to NRHFLS work injuries for welders employed in EFC:

Pain frequencies = (7.751+0.239HP-0.124SE-0.078 SC-0.077PE-0.068PB-0.048PTC)*

* t values are significant at $p < 0.01$; $R^2 = 0.353$; $F_{(1,1068)} = 97.235$ $p < 0.01$.

The significance of $R^2$ as tested by the F statistic indicates that the regression equation is significant. The regression results indicate health perception positively influences pain frequencies. This is evident from the positive signs of the estimated coefficient of the corresponding variable. This indicated that higher health perception among individual welders increases possibilities of experiencing more pain frequencies due to NRHFLS work injuries. Further, social environment, safety culture, physical environment, perceived benefit and physical task content negatively influences pain frequencies due to NRHFLS work injuries. This is evident from the negative signs of the estimated coefficients in the corresponding variables. This revealed that if improvement is considered in these six work factor domains can result in reduction of pain frequencies due to NRHFLS work injuries in the welder population. Health perception is found to be the most important work factor domain influencing pain frequencies due to NRHFLS work injuries followed by social environment, safety culture, physical environment, perceived benefit and physical task content.

## 5.3 INFLUENCE OF WORK FACTOR DOMAINS ON NON REPORTED HIGHLY FREQUENT LESS SEVERE WORK INJURIES AMONG THE WELDERS EMPLOYED IN ORGANISED SECTOR FABRICATION FIRMS

Based on the discussion in (See sec 5.1), the following null hypothesis is set to identify the dominant work factor domains that cause pain frequencies due to NRHFLS work injuries among welders employed by OSF firms.

**$H0_{5\text{-}2}$:** There is no significant influence of work factor domains in causing pain frequencies due to NRHFLS work injuries among the welders employed by OSF firms.

To test the null hypothesis $H0_{5\text{-}2}$ stepwise multiple regression analysis is performed with mean scores of the work factor domains. The descriptive statistics of the measures and correlation coefficients of work factor domains and pain frequencies are presented in Table 5.4. The results of the regression analysis shown in Table 5.5 and Table 5.6.

**Table 5.4** Descriptive statistics of work factor domains predicting pain frequencies due to NRHFLS work injuries among welders employed by OSF firms ($n_1 = 692$)

| | Zero order correlation | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **HP** | **SC** | **PTC** | **MTC** | **PE** | **SE** | **TE** | **PB** | **NRHFLS work injuries** |
| HP | | .06 | -.11* | -.24** | -.07 | -11** | -.08 | -.07 | .36** |
| SC | | | .54** | .15** | .47** | .52** | .21** | .32** | -.33** |
| PTC | | | | .11* | .36** | .44** | .23** | .30** | -.32** |
| MTC | | | | | .12* | .04 | .08 | .09 | -.08 |
| PE | | | | | | .32** | .16** | .22** | -.20** |
| SE | | | | | | | .23** | .34** | -.45** |
| TE | | | | | | | | .07 | -.11* |
| PB | | | | | | | | | -.24** |
| M | 16.36 | 34.40 | 15.22 | 27.01 | 18.57 | 15.47 | 16.84 | 7.61 | 3.96 |
| SD | 2.28 | 3.93 | 2.28 | 2.71 | 2.55 | 2.11 | 2.26 | 1.39 | 1.13 |

**p < .01; *p<.05

**Table 5.5** Model summary of step-wise multiple regression analysis for welders employed by OSF firms

| Model | R | $R^2$ | Adjusted $R^2$ | SE of the Estimate | Change Statistics | | | | | Durbin-Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $R^2$ Square | F Change | df1 | df2 | Sig. F Change | |
| 1 | .446[a] | .199 | .197 | 1.603 | .199 | 71.713 | 1 | 690 | .000** | |
| 2 | .547[b] | .299 | .295 | 1.502 | .100 | 41.027 | 1 | 689 | .000** | 1.809 |
| 3 | .560[c] | .314 | .307 | 1.489 | .015 | 6.075 | 1 | 688 | .014* | |

**p < 0.01, *p < 0.05

a. Predictors: (Constant), SE

b. Predictors: (Constant), SE, HP

c. Predictors: (Constant), SE, HP, SC

**Table 5.6** Results of stepwise regression for welders employed for OSF firms

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | Correlations | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Zero-order | Partial | Semi Partial | Tolerance | VIF |
| 1[a] | (Constant) | 8.961 | .522 | | 17.182 | .000** | | | | | |
| | SE | -.298 | .035 | -.446 | -8.468 | .000** | -.446 | -.446 | -.446 | 1.000 | 1.000 |
| | (Constant) | 4.654 | .831 | | 5.599 | .000** | | | | | |
| | $F_{(1,690} = 71.713$ $p < 0\ .01$, $R^2 = 0.199$ | | | | | | | | | | |
| 2[a] | (Constant) | 5.608 | .910 | | 6.161 | .000** | | | | | |
| | SE | -.274 | .033 | -.411 | -8.263 | .000** | -.446 | -.438 | -.408 | .987 | 1.013 |
| | HP | .247 | .039 | .318 | 6.405 | .000** | .364 | .354 | .316 | .987 | 1.013 |
| | $F_{(2,689)} = 61.353$ $p < 0\ .0$, , $R^2 = 0.299$ | | | | | | | | | | |
| 3[a] | (Constant) | 4.654 | .831 | | 5.599 | .000** | | | | | |
| | SE | -.224 | .039 | -.336 | -5.810 | .000** | -.446 | -.325 | -.285 | .717 | 1.395 |
| | HP | .249 | .038 | .320 | 6.502 | .000** | .364 | .359 | .318 | .987 | 1.013 |
| | SC | -.053 | .021 | -.142 | -2.465 | .000** | -.333 | -.144 | -.121 | .724 | 1.381 |
| | $F_{(3,688)} = 43.651$ $p < 0.01$, , $R^2 = 0.314$ | | | | | | | | | | |

[a] dependent variable NRHFLS work injury frequencies; $**p < 0.01$, $*p < 0.05$

**Interpretation:**

The Table 5.4, displays the descriptive information of means, standard deviation and correlation values between pain frequencies due to NRHFLS work injuries and eight work factors domains among welders employed by OSF firms. The Table 5.5shows model summary and Table 5.6 shows the results of stepwise multiple regression analysis.

The three ANOVA results reported in Table 5.5 corresponds to three models. The Table 5.6 shows the stepwise procedure that added one variable of work factor domain at a time to the model during the test. Each step results in a model and each successive step modifies the older model and replaces it with a new work factor domain. Each model is tested for its statistical significance. The df1 column in Table 5.5informs the final model was built in three steps; each step resulted in a statistically significant model. Examining the df1 column in Table 5.5 shows that one variable was added during each step (the degrees of freedom tracks regression effect as they are the counts of the number of predictors in the model). In model building it can be deduced that five work factor domains PTC, MTC, PE, TE and PB were excluded resulting in three work factor domains.

In Table 5.5, the Model summary presents $R^2$and adjusted $R^2$ values for each step along with the amount of $R^2$ change. In the first step Table 5.5, footnote beneath the model summary refers work factor domain-SE is entered into the Model - 1. The $R^2$ with that predictor in the model is (0.199), which is square of the multiple correlation coefficient (0.446) between SE and pain frequencies due to NRHFLS work injuries and is the value of $R^2$ change.

On the second step, a positive effect added to the Model 1 by entry of work factor domain - HP. The $R^2$ with both predictors in the Model 2 is (0.299); the Model 2 gains (0.100) in the value of $R^2$ (0.299 - 0.199 = 0.100) and this reflected in the $R^2$ change for that step.

On the third step, a positive effect added to the model by entry of work factor domain – SC. The $R^2$ with three predictors in the model is (0.314); the

Model-3 gains (0.015) in the value of $R^2$ (0.314 - 0.299 = 0.015) and this reflected in the $R^2$ change for that step.

Work factor domains HP, SC, PTC, MTC, PE, SE, TE and PB were used as predictors in stepwise multiple regression analysis to predict pain frequencies due to NRHFLS work injuries. The correlations of the work factor domain variables shown in Table 5.4. All the correlations were statistically significant, except between work factor domains HP and SC,PE, TE, PB, MTC and SE, TE, PB and between pain frequencies due to NRHFLS work injuries and TE, PB.

The ‘t’ values and its significance level for Model-3 in Table 5.6 revealed work factor domains significantly influences pain frequencies hence null hypothesis $H0_{5-2}$ to be rejected and hence alternate hypothesis proposing the difference at 0.01 level is accepted.

The Model-3 in the final step in Table 5.6 contained three work factor domains out of the eight work factor domains. Examining the model for multi-collinearity the largest variation inflation factors is less than 10 (Myers, 1990) and tolerance index is not less than 0.2 (Bower man and O’Connell, 1990). Hence, the selected Model-3 is within reasonable limits for multi collinearity condition. This is further supported by Durbin-Watson value of 1.809 in Table 5.5 that suggests the model is free from reasonable errors. The model is statistically significant, $F_{(1,\ 1068)} = 43.651$, $p < 0.01$, and approximately accounted for 30.7% of the variance of pain frequencies due to NRHFLS work injuries ($R^2 = 0.314$, Adjusted $R^2 = 0.307$).

Regression equation for Model-3 of work factor domains influencing pain frequencies due to NRHFLS work injuries for welders employed by OSF firms:

Pain frequencies = (4.654+ 0.249HP-0.224SE-0.053SC)*

* t values are significant at $p < 0.05$; $R^2 = 0.314$; $F_{(3,688)} = 43.651$. $p < 0.01$.

The significance of $R^2$ as tested by the F statistic indicates that the regression equation is significant. The regression results indicate health perception positively influences pain frequencies. This is evident from the positive sign of the estimated coefficient of the corresponding variable. This means that higher health perception among individual welders increases possibilities of experiencing more pain frequencies due to NRHFLS work injuries. Further, social environment, safety culture negatively influences pain frequencies due to NRHFLS work injuries. This is evident from the negative signs of the estimated coefficients of the corresponding variables.

This indicated that if improvement is considered in these three work factor domains, can result in reduction of pain frequencies due to NRHFLS work injuries among welder employed in OSF firms. Health perception is found to be the most important work factor domain influencing pain frequencies due to NRHFLS work injuries followed by social environment, safety culture.

## 5.4 INFLUENCE OF WORK FACTOR DOMAINS ON NON REPORTED HIGHLY FREQUENT LESS SEVERE WORK INJURIES AMONG THE WELDERS EMPLOYED IN UNORGANISED SECTOR FABRICATION FIRMS

Based on the discussion in (See sec 5.1), the following null hypothesis is set to identify the influence of work factor domains that cause pain frequencies due to NRHFLS work injuries among welders employed by USF firms.

**$H0_{5\text{-}3}$:** There is no significant influence of work factor domains in causing pain frequencies due to NRHFLS work injuries among the welders employed by USF firms.

To test the null hypothesis $H0_{5\text{-}3}$ stepwise multiple regression analysis is performed with mean scores of the work factor domains. The Table 5.7, displays the descriptive information of means, standard deviation and correlation values between pain frequencies due to NRHFLS work injuries and eight work factors domains among welders employed by USF firms. The Table 5.8 shows the model summary and Table 5.9 shows the results of stepwise multiple regression analysis.

**Table 5.7** Descriptive statistics of work factor domains predicting NRHFLS work injuries among welders employed by USF firms ($n_3$= 383)

| | Zero-order correlation | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variable** | **HP** | **SC** | **PTC** | **MTC** | **PE** | **SE** | **TE** | **PB** | **NRHFLS work injuries** |
| HP | | -.23** | -.18** | .04 | .06 | -.28** | .02 | .08 | .41** |
| SC | | | .51** | .24** | .43** | .57** | .22** | .26** | -.44** |
| PTC | | | | .24** | .43** | .48** | .20** | .28** | -.39** |
| MTC | | | | | .13* | .19** | .09 | .10* | -.09 |
| PE | | | | | | .37** | .14** | .26** | -.49** |
| SE | | | | | | | .14** | .25** | -.34** |
| TE | | | | | | | | .10* | -.18** |
| PB | | | | | | | | | -.11* |
| M | 18.13 | 27.34 | 12.03 | 26.56 | 16.36 | 11.72 | 15.90 | 6.26 | 6.78 |
| SD | 1.46 | 3.73 | 2.26 | 3.57 | 2.69 | 2.37 | 2.42 | 2.65 | 1.83 |

**p <0.01; *p < 0.05

**Table 5.8** Model summary of stepwise regression for Welders employed by USF firms

| Model | R | $R^2$ | Adjusted $R^2$ | SE of the Estimate | Change Statistics | | | | | Durbin Watson |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $R^2$ | F Change | df1 | df2 | Sig. F Change | |
| 1 | .485[a] | .235 | .234 | 1.839 | .235 | 155.147 | 1 | 381 | .000 | |
| 2 | .576[b] | .332 | .329 | 1.721 | .097 | 72.485 | 1 | 380 | .000 | |
| 3 | .600[c] | .360 | .356 | 1.685 | .028 | 22.434 | 1 | 379 | .000 | |
| 4 | .612[d] | .375 | .369 | 1.669 | .015 | 10.980 | 1 | 378 | .001 | 1.862 |
| 5 | .616[e] | .379 | .374 | 1.662 | .004 | 4.850 | 1 | 377 | .028 | |
| 6 | .620[f] | .384 | .377 | 1.657 | .005 | 3.876 | 1 | 376 | .048 | |

a. Predictors: (Constant), SC

b. Predictors: (Constant), SC,HP

c. Predictors: (Constant), SC,HP, PE

d. Predictors: (Constant), SC, HP, PE, SE

e. Predictors: (Constant), SC, HP, PE, SE, TE

f. Predictors: (Constant), SC, HP, PE, SE, TE, PTC

**Table 5.9** Results of stepwise regression for welders employed by USF firms

| Model | | Unstandardized Coefficients | | Standardized Coefficients | | | Correlations | | | Collinearity Statistics | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | B | SE | β | t | Sig. | Zero-order | Partial | Semi Partial | Tolerance | VIF |
| 1[a] | (Constant) | 11.217 | .494 | | 22.727 | .000** | | | | | |
| | SC | -.194 | .016 | -.485 | -12.456 | .000** | -.485 | -.485 | -.485 | 1.000 | 1.000 |
| | $F_{(1,381)} = 155.147$ $p < 0.01$, $R^2 = 0.235$ | | | | | | | | | | |
| 2[a] | (Constant) | 5.725 | .793 | | 7.216 | .000** | | | | | |
| | SC | .275 | .032 | .319 | 8.514 | .000** | .414 | .355 | .310 | .947 | 1.056 |
| | HP | -.164 | .015 | -.412 | -10.997 | .000** | -.485 | -.440 | -.401 | .947 | 1.056 |
| | $F_{(2,380)} = 124.818$, $p < 0 .01$, $R^2=0.332$ | | | | | | | | | | |
| 3[a] | (Constant) | 6.925 | .817 | | 8.473 | .000** | | | | | |
| | SC | .285 | .032 | .331 | 8.996 | .000** | .414 | .373 | .321 | .943 | 1.061 |
| | HP | -.131 | .016 | -.328 | -8.063 | .000** | -.485 | -.339 | -.288 | .769 | 1.300 |
| | PE | -.137 | .029 | -.188 | -4.737 | .000** | -.342 | -.207 | -.169 | .811 | 1.234 |
| | $F_{(3,379)} = 94.236$, $p < 0.01$, $R^2=0.360$ | | | | | | | | | | |
| 4[a] | (Constant) | 7.579 | .833 | | 9.099 | .000** | | | | | |
| | SC | -.106 | .032 | -.148 | -3.314 | .001** | -.444 | -.146 | -.117 | .625 | 1.600 |
| | HP | .264 | .032 | .306 | 8.217 | .000** | .414 | .345 | .290 | .904 | 1.107 |
| | PE | -.104 | .018 | -.260 | -5.737 | .000** | -.485 | -.248 | -.203 | .609 | 1.642 |
| | SE | -.119 | .029 | -.163 | -4.076 | .000** | -.342 | -.179 | -.144 | .782 | 1.279 |
| | $F_{(4,378)} = 74.827$, $p < 0.01$, $R^2=0.375$ | | | | | | | | | | |
| 5[a] | (Constant) | 8.391 | .908 | | 9.241 | . .000** | | | | | |
| | SC | -.105 | .032 | -.147 | -3.288 | .000** | -.444 | -.145 | -.116 | .625 | 1.601 |
| | HP | .267 | .032 | .310 | 8.346 | .000** | .414 | .350 | .294 | .901 | 1.109 |
| | PE | -.097 | .018 | -.244 | -5.345 | .000** | -.485 | -.232 | -.188 | .594 | 1.682 |
| | SE | -.116 | .029 | -.159 | -3.991 | .000** | -.342 | -.176 | -.141 | .781 | 1.281 |
| | TE | -.069 | .031 | -.080 | -2.202 | .028* | -.176 | -.098 | -.078 | .948 | 1.055 |
| | $F_{(5,377)} = 61.292$, $p < 0.01$, $R^2=0.379$ | | | | | | | | | | |
| 6[a] | (Constant) | 8.540 | .909 | | 9.400 | .000** | | | | | |
| | SC | -.092 | .033 | -.222 | -2.803 | .005** | -.444 | -.124 | -.098 | .596 | 1.677 |
| | HP | .263 | .032 | .305 | 8.226 | .000** | .414 | .346 | .289 | .898 | 1.114 |
| | PE | -.089 | .019 | -.127 | -4.739 | .000** | -.485 | -.208 | -.166 | .561 | 1.783 |
| | SE | -.102 | .030 | -.140 | -3.416 | .001** | -.342 | -.151 | -.120 | .736 | 1.359 |
| | TE | -.063 | .031 | -.072 | -1.995 | .047* | -.176 | -.089 | -.070 | .938 | 1.067 |
| | PTC | -.065 | .033 | -.086 | -1.969 | .049* | -.391 | -.088 | -.069 | .642 | 1.557 |
| | $F_{(6,376)} = 52.016$, $p < 0.01$, $R^2=0.384$ | | | | | | | | | | |

[a] dependent variable NRHFLS work injury frequencies; $^{**}p < 0.01$, $^{*}p < 0.05$

**Interpretation**

Work factor domains HP, SC, PTC, MTC, PE, SE, TE and PB were used as predictors in stepwise multiple regression analysis to predict pain frequencies due to NRHFLS work injuries among welders employed in USF firms.

The Table 5.7 displays the descriptive information of means, standard deviation and correlation matrix between pain frequencies due to NRHFLS work injuries and eight work factors domains among welders employed by USF firms. Table 5.8 shows the model summary and Table 5.9 shows the result of stepwise multiple regression analysis.

The six ANOVAs result reported corresponds to six models in Table 5.8. Examining the df1 column in Table 5.8 informs the final model was built in six steps; each step resulted in a statistically significant model. Examining the df1 column in Table 5.8 shows that one work factor domain variable was added during each step (the degrees of freedom tracks regression effect as they are the counts of the number of predictors in the model). In model building it can be deduced that two work factor domains MTC and PB were excluded resulting in six-work factor domains.

In Table 5.8, the Model summary presents $R^2$and Adjusted $R^2$ values for each step along with the amount of R square change. In the first step Table 5.8 footnote beneath the model summary refers work factor domain-SC is entered into the Model - 1. The $R^2$ with that predictor in the model is (0.235), which is square of the multiple correlation coefficient (0.485) between SC and pain frequencies due to NRHFLS work injuries and is the value of $R^2$ square change.

On the second step, a positive effect added to the model by entry of work factor domain - HP. The $R^2$ with both predictors in the Model 2 is

(0.332).; the Model 2 gains (0.097) in the value of $R^2$ (0.332 - 0.235 = 0.097) and this reflected in the $R^2$ change for that step.

On the third step, a positive effect added to the model by entry of work factor domain – PE. The $R^2$ with three predictors in the model is (0.360) the Model-3 gains 0.028 in the value of $R^2$ (0.360- 0.232 = 0.028) and this reflected in the $R^2$ change for that step.

On the fourth step, a positive effect added to the model by the entry of the work factor domain – SE. The $R^2$ with four predictors in the model is (0.375) the Model-4 gains .015 in the value of $R^2$ (0.375- 0.360 = 0.015) and this reflected in the $R^2$ change for that step.

On the fifth step positive effect added to the model by the entry of the work factor domain – TE. The $R^2$ with five predictors in the model is (0.379). The $R^2$ (0.379 - 0.375 = 0.004) and this reflected in the $R^2$ change for that step.

On the final step positive effect added to the model by the entry of the work factor domain – PTC. The $R^2$ with six predictors in the model is (0.384). The $R^2$ (0.384 - 0.379 = 0.005) and this reflected in the $R^2$ change for that step.

The correlations of the work factor domain variables is shown in Table 5.7, all the correlation were statistically significant, except between HP and MTC, PE, TE, PB and MTC and TE.

The 't' values and its significance level for Model-3 in Table 5.9 revealed work factor domains significantly influences pain frequencies hence null hypothesis $H0_{5\text{-}3}$ to be rejected and hence alternate hypothesis proposing the difference at 0.01 level is accepted

The Model-6 in the final step in Table 5.9 contain six work factor domains out of eight work factor domains. Examining the model for multi collinearity in Table 5.9 the largest variation inflation factors is less than 10

(Myers, 1990) and tolerance index is not less than 0.2 (Bower man and O'Connell, 1990). Hence, the selected Model-6 is within reasonable limits of multi collinearity condition. This is further supported by Durbin-Watson value of 1.862 in Table 5.8 that suggests the model is free from reasonable errors. The model is statistically significant, $F_{(6,\ 376)} = 52.016$, $p < .01$, and accounts for approximately 37.7% of the variance of NRHFLS work injury frequency ($R^2 = .384$, Adjusted $R^2 = .377$).

Regression equation for Model-6 of work factor domains influencing pain frequencies due to NRHFLS work injuries for welders employed by OSF firms:

Pain frequencies = (8.540+0.263HP - 0.102SE – 0.092SC – 0.089PE – 0.065PTC - 0.063TE)*

* t values are significant at $p < 0.01$; $R^2 = .384$; $F_{(6,376)} = 52.016$, $p < 0.01$.

The significance of $R^2$ as tested by the F statistic indicates that the regression equation is significant. The regression results indicated health perception positively influences pain frequencies. This is evident from the positive signs of the estimated coefficient of the corresponding variable. This means that higher health perception among individual welders increases possibilities of experiencing more pain frequencies due to NRHFLS work injuries. Further, social environment, safety culture, physical environment, perceived benefit and physical task content negatively influences pain frequencies due to NRHFLS work injuries. This is evident from the negative signs of the estimated coefficients of the corresponding variables.

This indicated that if improvement is considered in these six work factor domains, can result in reduction of pain frequencies due to NRHFLS work injuries among welder employed in USF firms. Health perception was found to be the most important work factor domain influencing pain frequencies due to

NRHFLS work injuries followed by social environment, safety culture, physical environment, physical task content and technical environment.

### 5.5 SUMMARY AND CONCLUSIONS

The Table 5.10 shows the summarized descending order of standardized β values of regression analysis performed to identify the influential work factor domains on pain frequencies due to NRHFLS work injuries.

**Table 5.10** Summary of indexed standardized β values related to work factor domains in welder population and welders employed by OSF and USF firms.

| Welder population - EFC | | Welders - OSF firms | | Welders | USF -firms |
|---|---|---|---|---|---|
| **WFD** | **β** | **WFD** | **β** | **WFD** | **β** |
| HP | 0.290 | SE | -.336 | HP | 0.305 |
| SC | -0.200 | HP | .320 | SC | -0.222 |
| SE | -0.178 | SC | -.142 | SE | -0.140 |
| PE | -0.108 | | | PE | -0.127 |
| PB | -0.070 | | | PTC | -0.086 |
| PTC | -0.066 | | | TE | -0.072 |

Work factor domains health perception has positive influence and safety culture, social environment, physical environment, perceived benefit and physical task content has negative influence on pain frequencies due to NRHFLS work injuries.

Indexing and examining the β weights of work factor domains in Table 5.10 for welder population. Descending order of β weights of work factors domain indicate positive sign for health perception followed by negative sign for safety culture, social environment, physical environment, perceived benefit and physical task content for pain frequencies due to NRHFLS work injuries.

Indexing and examining the β weights of work factor domains in Table 5.10 for welders employed by OSF firms. Descending order of β weights indicate negative sign for social environment, safety culture and positive sign for health perception.

Indexing and examining the β weights of work factor domains in Table 5.10 for welders employed by USF firms indicate positive sign for health perception and negative sign for - safety culture, social environment, physical environment, physical task content and technical environment.

Examining for common work factor domains appearing in Table 5.10 across welder population and welders employed by OSF and USF firms, health perception, safety culture and social environment appear commonly across the three groups and hence can be considered for intervention initiatives.

Health perception β value is high and positive that indicates presence of high latent energy among welders. This in turn can be a reason for causing work injuries for example, exhibiting bull type attitude by welders. By doing so the welder compromises the safety procedures commonly done due to lack of training and the reason may be for their sustainability of the job. This finding is in tune with the literature findings of higher latent energy among welders as cause of work injuries among welders in developing countries (Epko, 2012) and its reasons are to be investigated. Negative sign for safety and social environment suggests improvement in these work factor domains for intervention initiatives among welders employed by firms in the cluster to mitigate pain frequencies due to NRHLS work injuries.

………ꕤ………

*Chapter* **6**

# MODELING THE INFLUENCE OF PERSONAL ATTRIBUTES AND EMPLOYMENT FACTORS ON MUSCULOSKELETAL DISORDER PAIN AMONG WELDERS

*Contents*



## 6.1 INTRODUCTION

The study in the chapter was carried out with the following objectives

- To model and assess influential personal attributes and employment factors on musculoskeletal disorder pain in welders body region for weekly prevalence.
- To model and assess influential personal attribute and employment factors on musculoskeletal disorder pain in welders body region for annual prevalence.
- To model and assess influential personal attribute and employment factors on musculoskeletal disorder pain in welders body region for annual disability, which in turn causes presenteeism phenomenon.

## 6.2 MODELING OF MUSCULOSKELETAL DISORDER PAIN IN WELDERS BODY REGION IN EFC

### 6.2.1 Modeling measures

#### *6.2.1.1 Criterion variable*

Following the discussions (See sec 3.4.1), the criterion variable considered in this part of study is self-reported musculoskeletal disorder pain response. The self reported pain is modeled for nine body regions of welders employed in EFC for weekly prevalence, annual prevalence and annual disability. To measure musculoskeletal disorder pain in nine body regions for weekly prevalence, annual prevalence and annual disability (See sec 3.3.2.4) standardized version of Modified Nordic Questionnaire (MNQ) by Dickinson et al. (1992) was employed.

#### *6.2.1.2 Predictor variables*

The predictor variables selected for the study are (See sec 3.4.2) personal attribute and employment factors.

Personal Attribute (PA): age and experience are considered as continuous variable. Employment Factors (EF) - Working hours as a variable is dichotomized, coded as '1' for regular working hours and coded as '2' for extended working hours. Shift work as a variable is dichotomized and coded as '1' for welders employed in shift work and coded as '2' for non-shift (general shift) work. Nature of employment as a variable is dichotomized and coded as '1' for welders employed in regular rolls and coded as '2' for adhoc nature of employment. Mode of apprenticeship training dichotomized and coded as '1' for welder who had acquired trade knowledge through institutional training (for example, an ITI certificate) and coded as '2' if welder had acquired trade knowledge through on-the-job training method. Physical workload is computed by converting average number of welding rods used during last one month into kilograms of metals deposit and considered as continuous variable.

## 6.3 PERCENTAGE ANALYSIS OF MUSCULOSKELETAL DISORDER PAIN FOR WEEKLY PREVALENCE, ANNUAL PREVALENCE AND ANNUAL DISABILITY

Percentage wise distribution of MSD pain in welders body region measured by MNQ is shown in Table 6.1 for weekly prevalence, annual prevalence and annual disability.

**Table 6.1** Percentage distribution of MSD pain in body regions of welder for weekly prevalence, annual prevalence and annual disability (N = 1075)

| Body region | Weekly prevalence Yes(%) | Annual prevalence Yes(%) | Annual disability Yes(%) |
|---|---|---|---|
| Neck | 684(63.6) | 887(82.5) | 482(44.8) |
| Shoulder | 637(59.3) | 612(56.9) | 633(58.9) |
| Elbow | 819(76.2) | 538(50.0) | 419(39.0) |
| Wrist/Hands | 1034(96.2) | 762(70.9) | 662(61.6) |
| Upper back | 533(49.6) | 519(48.3) | 495(46.0) |
| Lower back | 563(49.9) | 561(52.2) | 823(76.6) |
| Hip/Thigh/Buttock | 517(48.1) | 552(51.3) | 490(45.6) |
| Knees | 548(51.0) | 522(48.6) | 526(49.9) |
| Ankle/Feet | 568(52.87) | 544(50.6) | 575(53.5) |

## 6.4 PERSONAL ATTRIBUTES AND EMPLOYMENT FACTORS INFLUENCING MUSCULOSKELETAL DISORDER PAIN AMONG WELDERS BODY REGION FOR WEEKLY PREVALENCE

The pain response 'absence or presence of MSD pain' in neck, shoulder, elbow, wrist/hands, upper back, lower back, hip/thighs/buttocks, knees and ankles/feet for weekly prevalence (during last seven days) is considered as criterion variable. The predictor variables considered are PA - age and experience; EF - working hours, shift work, nature of employment, mode of apprenticeship training and physical workload. The above variables are modeled by binary logistic regression and the results are shown in following sections.

### 6.4.1 Neck region – weekly prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in the neck region among the welders for weekly prevalence. The following hypothesis is advanced.

**$H0_{6-1}$:** The personal attributes and employment factors have no influence on weekly prevalence of MSD pain in neck region among the welders in EFC.

To test the null hypothesis $H0_{6-1}$ binary logistic regression was performed. The results are shown in Table 6.2.

**Table 6.2** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in neck region for weekly prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Odds ratio | Lower | Upper |
| Age | .004 | .0 06 | .417 | 1 | .519 | 1.004 | .992 | 1.016 |
| Experience | -.013 | .008 | 2.497 | 1 | .114 | .987 | .971 | 1.003 |
| Working hours | -.138 | .157 | .768 | 1 | .381 | .871 | .640 | 1.186 |
| Shift work | .169 | .287 | .346 | 1 | .556 | 1.184 | .675 | 2.077 |
| Nature of employment | .008 | .160 | .002 | 1 | .962 | 1.008 | .736 | 1.380 |
| Mode of apprenticeship training | -.191 | .157 | 1.484 | 1 | .223 | .826 | .607 | 1.124 |
| Physical work load | .043 | .051 | .706 | 1 | .401 | 1.044 | .944 | 1.155 |
| Constant | .716 | .689 | 1.079 | 1 | .299 | 2.047 | | |

Note: absence of MSD pain is coded as '0', presence as '1'; (0.005 Cox and Snell) and (0.007 Nagelkerke), Model $\chi^2$ (7) = 5.83, p = 0.538.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain in 'neck region' for weekly prevalence among welders in EFC. The result ($\chi^2$ (7, 1075) = 5.83, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in neck region among welders in EFC for weekly prevalence. This result in turn supports the null hypothesis $H0_{6-1}$.

### 6.4.2 Shoulder region – weekly prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in shoulder region among the welders for weekly prevalence. The following hypothesis is advanced.

**$H0_{6-2}$:** The personal attributes and employment factors have no influence on weekly prevalence of MSD pain in shoulder region among the welders in EFC.

To test the null hypothesis $H0_{6-2}$ binary logistic regression was performed. The results are shown in Table 6.3.

**Table 6.3** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in shoulder region among welders for weekly prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | | VIF |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper | |
| Age | -0.008 | 0.006 | 1.641 | 1 | 0.200 | 0.992 | 0.98 | 1.004 | 1.133 |
| Experience | -0.001 | 0.008 | 0.022 | 1 | 0.881 | 0.999 | 0.982 | 1.015 | 1.113 |
| Working hours | 0.16 | 0.156 | 1.045 | 1 | 0.307 | 1.173 | 0.864 | 1.593 | 1.498 |
| Shift work | 1.954 | 0.297 | 43.139 | 1 | 0.000 | 7.055 | 3.938 | 12.639 | 4.705 |
| Nature of employment | -0.39 | 0.157 | 6.182 | 1 | 0.013 | 0.677 | 0.498 | 0.921 | 1.187 |
| Mode of apprenticeship training | 0.054 | 0.153 | 0.123 | 1 | 0.726 | 1.055 | 0.782 | 1.423 | 1.321 |
| Physical work load | 0.011 | 0.051 | 0.043 | 1 | 0.835 | 1.011 | 0.914 | 1.117 | 3.427 |
| Constant | -1.575 | 0.691 | 5.192 | 1 | 0.023 | 0.207 | | | |

Note: absence of MSD pain is coded as '0', presence as '1'; (0.135 Cox and Snell) and (0.127 Nagelkerke), Model $\chi^2$ (7) = 147.85, p = 0.000.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables of age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'shoulder region' for weekly prevalence among welders in EFC. The result of binary logistic regression ($\chi^2$ (7, 1075) = 147.85, $p < 0.01$) shows significant influence of predictor variables on MSD pain in shoulder region for weekly prevalence. Hence, the result in turn rejects the null hypothesis $H0_{6\text{-}2}$.

For validating the relationship, initially the Log Likelihood value (-2 Log Likelihood or -2LL) was examined for its significance. In this model the initial -2LL value is 1432 which is the measure of the model with no independent variables, i.e., only with an intercept or a constant. The final -2LL value was 1284.85 which is the measure computed after all the predictors have been entered into binary logistic regression. The difference between these two measures is the model $\chi^2$ (1432 - 1284.15 = 147.85) value which is tested for statistical significance. The $\chi^2$ value of 147.85 is statistically significant at $p < 0.01$. Hence it concluded that significant influence exists between criterion variable and the set of .predictor variables.

To check whether multicollinearity condition is within reasonable limits, the values of Variation Inflation Factor (VIF) were examined in Table 6.3. The values in VIF columns in the Table 6.3 shows no values above 10 (Myers, 1990). The range of values in VIF column in Table 6.3 indicates multi collinearity is within reasonable limits hence the model can be considered for interpretation.

The 'Wald statistic' significance column in Table 6.3 shows shift work to be significant at $p < 0.01$. The significance column of Wald statistic in Table 6.3

shows shift work as the significant predictor of MSD pain in shoulder region for weekly prevalence among welders in EFC. The Exp (B) column of Table 6.3 shows a value of 7.055 for shift work which is considerably greater than one, hence it is concluded that shift work as a factor influence MSD pain on shoulder region among welders employed in EFC.

The inferential Goodness-of-fit Hosmer and Lemeshow test yields a $\chi^2$ (8) value of 5.99 at $p > 0.01$, which is insignificant. This in turn indicates that the model fits the data well and the null hypothesis of a good model fit is acceptable.

Considering the measures discussed it is concluded that shiftwork as a factor influence weekly prevalence of MSD pain in shoulder region of welders employed in EFC.

### 6.4.3 Elbow region – weekly prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in elbow region among the welders for weekly prevalence. The following hypothesis is advanced.

**$H0_{6\text{-}3}$:** The personal attributes and employment factors have no influence on weekly prevalence of MSD pain in elbow region among the welders in EFC.

To test the null hypothesis $H0_{6\text{-}3}$ binary logistic regression was performed. The results are shown in Table 6.4.

**Table 6.4** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in elbow region among welders for weekly prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | .000 | .007 | .003 | 1 | .957 | 1.000 | .987 | 1.014 |
| Experience | -.001 | .009 | .014 | 1 | .907 | .999 | .981 | 1.017 |
| Working hours | .106 | .175 | .363 | 1 | .547 | 1.111 | .788 | 1.567 |
| Shift work | .058 | .325 | .031 | 1 | .859 | 1.059 | .560 | 2.005 |
| Nature of employment | .028 | .180 | .024 | 1 | .877 | 1.028 | .723 | 1.462 |
| Mode of apprenticeship training | -.110 | .176 | .390 | 1 | .532 | .896 | .634 | 1.265 |
| Physical work load | -.023 | .059 | .157 | 1 | .692 | .977 | .871 | 1.096 |
| Constant | 1.148 | .780 | 2.167 | 1 | .141 | 3.151 | | |

Note: absence of MSD pain is coded as '0', presence as '1'; (0.001Cox and Snell) and (0.002 Nagelkerke), Model $\chi 2$ (7, 1075) = 1.12, p = 0.993.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'elbow region' for weekly prevalence among welders in EFC. The result ($\chi^2$ (7, 1075) = 1.12, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in elbow region among welders in EFC for weekly prevalence. Hence, the result in turn supports the null hypothesis $H0_{6\text{-}3}$.

### 6.4.4 Wrist/Hand region – weekly prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in wrist/hand region among the welders for weekly prevalence. The following hypothesis is advanced.

**$H0_{6\text{-}4}$:** The personal attributes and employment factors have no influence on weekly prevalence of MSD pain in wrist/hand region among the welders in EFC

To test the null hypothesis $H0_{6\text{-}4}$ binary logistic regression was performed. The results are shown in Table 6.5.

**Table 6.5** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in wrist/hand region among welders for weekly prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) Lower | 95% C.I .for Exp (B) Upper |
|---|---|---|---|---|---|---|---|---|
| Age | .020 | .015 | 1.863 | 1 | .172 | 1.020 | .991 | 1.051 |
| Experience | -.050 | .021 | 5.711 | 1 | .017 | .952 | .914 | .991 |
| Working hours | .291 | .359 | .656 | 1 | .418 | 1.338 | .661 | 2.705 |
| Shift work | .993 | .711 | 1.949 | 1 | .163 | 2.699 | .670 | 10.876 |
| Nature of employment | .011 | .372 | .001 | 1 | .976 | 1.011 | .488 | 2.095 |
| Mode of apprenticeship training | -.282 | .362 | .606 | 1 | .436 | .754 | .371 | 1.534 |
| Physical work load | .012 | .121 | .009 | 1 | .923 | 1.012 | .798 | 1.283 |
| Constant | 1.903 | 1.634 | 1.357 | 1 | .244 | 6.705 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.012 Cox and Snell) and (0.044 Nagelkerke), Model $\chi2$ (7) = 13.24, p = 0.067.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'wrist/hand region' for weekly prevalence among welders in EFC. The result ($\chi^2$ (7, 1075) = 13.24, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in wrist/hand region among welders in EFC for weekly prevalence. Hence, the result supports the null hypothesis $H0_{6\text{-}4}$.

### 6.4.5 Upper back region – weekly prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in the upper back region among the welders for weekly prevalence. The following hypothesis is advanced.

**$H0_{6\text{-}5}$:** The personal attributes and employment factors have no influence on weekly prevalence of MSD pain in upper back region among the welders in EFC.

To test the null hypothesis $H0_{6\text{-}5}$ binary logistic regression was performed. The results are shown in Table 6.6.

**Table 6.6** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in upper back region among welders for weekly prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | -.005 | .006 | .635 | 1 | .426 | .995 | .984 | 1.007 |
| Experience | .004 | .008 | .256 | 1 | .613 | 1.004 | .988 | 1.020 |
| Working hours | .002 | .151 | .000 | 1 | .991 | 1.002 | .745 | 1.347 |
| Shift work | -.368 | .278 | 1.749 | 1 | .186 | .692 | .401 | 1.194 |
| Nature of employment | .254 | .155 | 2.693 | 1 | .101 | 1.289 | .952 | 1.745 |
| Mode of apprenticeship training | -.231 | .151 | 2.330 | 1 | .127 | .794 | .590 | 1.068 |
| Physical work load | -.055 | .050 | 1.191 | 1 | .275 | .947 | .858 | 1.044 |
| Constant | .719 | .667 | 1.160 | 1 | .281 | 2.051 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.009 Cox and Snell) and (0.012 Nagelkerke), Model $\chi^2$ (7, 1075) = 9.42, p = 0.224.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'upper back' for weekly prevalence among welders in EFC. The result ($\chi^2$ (7, 1075) = 9.42, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in upper back region among welders in EFC for weekly prevalence. Hence, the result supports the null hypothesis $H0_{6-5}$.

**6.4.6 Lower back region – weekly prevalence**

This section is on modeling the influence of personal attributes and employment factors on MSD pain in the lower back region among the welders for weekly prevalence. The following hypothesis is advanced.

**$H0_{6-6}$:** The personal attributes and employment factors have no influence on weekly prevalence of MSD pain in lower back region among the welders in EFC.

To test the null hypothesis $H0_{6-6}$ binary logistic regression was performed. The results are shown in Table 6.7.

**Table 6.7** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in lower back region among for weekly prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | .002 | .006 | .167 | 1 | .683 | 1.002 | .991 | 1.014 |
| Experience | -.008 | .008 | 1.035 | 1 | .309 | .992 | .976 | 1.008 |
| Working hours | .029 | .151 | .037 | 1 | .848 | 1.029 | .766 | 1.383 |
| Shift work | .305 | .278 | 1.200 | 1 | .273 | 1.356 | .786 | 2.341 |
| Nature of employment | -.058 | .154 | .143 | 1 | .705 | .943 | .697 | 1.276 |
| Mode of apprenticeship training | -.121 | .151 | .639 | 1 | .424 | .886 | .659 | 1.192 |
| Physical work load | .094 | .050 | 3.510 | 1 | .061 | 1.098 | .996 | 1.211 |
| Constant | -.454 | .666 | .466 | 1 | .495 | .635 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.009 Cox and Snell) and (0.012 Nagelkerke), Model $\chi 2$ (7, 1075) = 6.69, p = 0.462.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'lower back' region for weekly prevalence among welders in EFC. The result ($\chi^2$ (7) = 6.69, p > 0.01) shows no significant influence of predictor variables on MSD pain in lower back region among welders in EFC for weekly prevalence. Hence, the result supports the null hypothesis $H0_{6\text{-}6}$.

### 6.4.7 Hip/Thighs/Buttock region – weekly prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in the hip/thigh/buttock region among the welders for weekly prevalence. The following hypothesis is advanced.

**$H0_{6\text{-}7}$:** The personal attributes and employment factors have no influence on weekly prevalence of MSD pain in hip/thigh/buttock region among the welders in EFC.

To test the null hypothesis $H0_{6\text{-}7}$ binary logistic regression was performed. The results are shown in Table 6.8.

**Table 6.8** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in hip/thigh/buttock region among welders for weekly prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | -.004 | .006 | .504 | 1 | .478 | .996 | .985 | 1.007 |
| Experience | .004 | .008 | .247 | 1 | .619 | 1.004 | .988 | 1.020 |
| Working hours | -.169 | .151 | 1.258 | 1 | .262 | .845 | .629 | 1.135 |
| Shift work | -.169 | .277 | .371 | 1 | .542 | .845 | .491 | 1.454 |
| Nature of employment | .060 | .154 | .154 | 1 | .695 | 1.062 | .785 | 1.437 |
| Mode of apprenticeship training | -.004 | .151 | .001 | 1 | .978 | .996 | .741 | 1.338 |
| Physical work load | -.037 | .050 | .551 | 1 | .458 | .964 | .874 | 1.062 |
| Constant | .516 | .664 | .604 | 1 | .437 | 1.675 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.003 Cox and Snell) and (0.004 Nagelkerke), Model $\chi 2$ (7, 1075) = 2.83 p = 0.900.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'hip/thigh/buttock' region for weekly prevalence among welders in EFC. The result ($\chi^2$ (7) = 2.83, p > 0.01) shows no significant influence of predictor variables on MSD pain in hip/thigh/buttock region among welders in EFC for weekly prevalence. Hence, the result supports the null hypothesis $H0_{6-7}$.

### 6.4.8 Knee region – weekly prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in the knee region among the welders for weekly prevalence. The following hypothesis is advanced.

**$H0_{6-8}$:** The personal attributes and employment factors have no influence on weekly prevalence of MSD pain in knee region among the welders in EFC.

To test the null hypothesis $H0_{6-8}$ binary logistic regression was performed. The results are shown in Table 6.9.

**Table 6.9** Parameter estimates of multinomial logistic regression for personal attributes and employment factors on MSD pain in knee region among welders for weekly prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | .007 | .006 | 1.238 | 1 | .266 | 1.007 | .995 | 1.018 |
| Experience | .004 | .008 | .253 | 1 | .615 | 1.004 | .988 | 1.020 |
| Working hours | .094 | .154 | .372 | 1 | .542 | 1.099 | .812 | 1.486 |
| Shift work | -.273 | .286 | .913 | 1 | .339 | .761 | .434 | 1.333 |
| Nature of employment | -.173 | .159 | 1.179 | 1 | .278 | .841 | .616 | 1.149 |
| Mode of apprenticeship training | .053 | .155 | .115 | 1 | .734 | 1.054 | .778 | 1.428 |
| Physical work load | -.029 | .052 | .309 | 1 | .579 | .972 | .878 | 1.075 |
| Constant | .660 | .686 | .925 | 1 | .336 | 1.934 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.007 Cox and Snell) and (0.009 Nagelkerke), Model $\chi 2$ (7, 1075) = 7.37, p = 0.391.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on knee region for weekly prevalence among welders in EFC. The result ($\chi^2$ (7) = 7.37, $p > 0.01$) shows no significant influence of predictor variables on MSD pain knee region among welders in EFC for weekly prevalence. Hence, the result supports the null hypothesis $H0_{6\text{-}8}$.

### 6.4.9Ankle/Feet region – weekly prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in the ankle/feet region among the welders for weekly prevalence. The following hypothesis is advanced.

**$H0_{6\text{-}9}$:** The personal attribute and employment factor have no influence on weekly prevalence of MSD pain in ankle/feet region among the welders in EFC.

To test the null hypothesis $H0_{6\text{-}9}$, binary logistic regression was performed. The results are shown in Table 6.10.

**Table 6.10** Parameter estimates of multinomial logistic regression for personal attributes and employment factors on MSD pain in ankle/feet region among welders for weekly prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | .003 | .006 | .312 | 1 | .577 | 1.003 | .992 | 1.015 |
| Experience | -.010 | .008 | 1.428 | 1 | .232 | .990 | .975 | 1.006 |
| Working hours | .038 | .151 | .063 | 1 | .801 | 1.039 | .773 | 1.396 |
| Shift work | -.011 | .277 | .002 | 1 | .967 | .989 | .575 | 1.701 |
| Nature of employment | -.062 | .154 | .159 | 1 | .690 | .940 | .695 | 1.273 |
| Mode of apprenticeship training | .017 | .151 | .013 | 1 | .909 | 1.017 | .757 | 1.368 |
| Physical work load | .016 | .050 | .104 | 1 | .747 | 1.016 | .922 | 1.120 |
| Constant | .101 | .664 | .023 | 1 | .880 | 1.106 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.002 Cox and Snell) and (0.003 Nagelkerke), Model $\chi 2$ (7, 1075) = 2.35, p = 0.938.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on ‘ankle/feet region for weekly prevalence among welders in EFC. The results shows no significant influence of predictor variables on MSD pain in ankle/feet region among welders in EFC for weekly prevalence ($\chi^2$ (7) = 2.35, p > 0.01). Hence, the result supports the null hypothesis $H0_{6-9}$.

## 6.5 PERSONAL ATTRIBUTES AND EMPLOYMENT FACTORS INFLUENCING MUSCULOSKELETAL DISORDER PAIN AMONG WELDERS BODY REGION FOR ANNUAL PREVALENCE

### 6.5.1 Neck region – annual prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in the neck region among the welders for annual prevalence. The following hypothesis is advanced.

**$H0_{6-10}$:** The personal attributes and employment factors have no influence on annual prevalence of MSD pain in neck region among the welders in EFC.

To test the null hypothesis $H0_{6-10}$ binary logistic regression was performed. The results are shown in Table 6.11.

**Table 6.11** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in neck region among welders for annual prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | -.009 | .008 | 1.470 | 1 | .225 | .991 | .976 | 1.006 |
| Experience | .008 | .011 | .561 | 1 | .454 | 1.008 | .987 | 1.029 |
| Working hours | -.128 | .200 | .407 | 1 | .524 | .880 | .594 | 1.303 |
| Shift work | .163 | .362 | .201 | 1 | .654 | 1.176 | .578 | 2.394 |
| Nature of employment | -.418 | .213 | 3.837 | 1 | .050 | .658 | .433 | 1.000 |
| Mode of apprenticeship training | -.044 | .200 | .049 | 1 | .824 | .957 | .647 | 1.415 |
| Physical work load | .018 | .065 | .076 | 1 | .783 | 1.018 | .896 | 1.157 |
| Constant | 2.503 | .889 | 7.934 | 1 | .005 | 12.218 | | |

Note: presence of MSD pain is coded as **'1'**, absence as **'0'**; (0.005 Cox and Snell) and (0.009 Nagelkerke), Model $\chi^2$ (7, 1075) = 5.88, p = 0.554.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on neck region for annual prevalence among welders in EFC. The result ($\chi^2$ (7) = 5.88, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in neck region among welders in EFC for annual prevalence. Hence, the result supports the null hypothesis $H0_{6-10}$.

### 6.5.2 Shoulder region – annual prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in the shoulder region among the welders for annual prevalence. The following hypothesis is advanced.

**$H0_{6-11}$:** The personal attributes and employment factors have no influence on annual prevalence of MSD pain in shoulder region among the welders in EFC.

To test the null hypothesis $H0_{6-11}$ binary logistic regression was performed. The results are shown in Table 6.12.

**Table 6.12** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in shoulder region among welders for annual prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | | VIF |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper | |
| Age | -0.003 | 0.006 | 0.189 | 1 | 0.663 | 0.997 | 0.986 | 1.009 | 1.133 |
| Experience | -0.002 | 0.008 | 0.041 | 1 | 0.840 | 0.998 | 0.983 | 1.014 | 1.113 |
| Working hours | 0.257 | 0.152 | 2.867 | 1 | 0.090 | 1.294 | 0.96 | 1.743 | 1.498 |
| Shift work | 0.57 | 0.28 | 4.148 | 1 | 0.042 | 1.769 | 1.022 | 3.063 | 4.705 |
| Nature of employment | 0.002 | 0.155 | 0 | 1 | 0.99 | 1.002 | 0.74 | 1.357 | 1.187 |
| Mode of apprenticeship training | 0.024 | 0.151 | 0.025 | 1 | 0.875 | 1.024 | 0.762 | 1.377 | 1.321 |
| Physical work load | -0.025 | 0.05 | 0.25 | 1 | 0.617 | 0.975 | 0.884 | 1.076 | 3.427 |
| Constant | -0.713 | 0.669 | 1.136 | 1 | 0.287 | 0.49 | | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.181 Cox and Snell) and (0.241 Nagelkerke), Model $\chi^2$ (7, 1075) = 19.54, p = 0.007.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables of age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on ‘shoulder region’ for annual prevalence among welders in EFC. The results of binary logistic regression ($\chi^2$ (7, 1075) = 19.54, $p < 0.01$) shows influence of predictor variables on MSD pain in shoulder region for annual prevalence. Hence, the result reveals to reject the null hypothesis $H0_{6\text{-}11}$.

For validating the relationship, initially the Log Likelihood value (-2 Log Likelihood or -2LL) was examined for its significance. In this model the initial -2LL value is 1431 which is the measure of the model with no independent variables, i.e., only with an intercept or a constant. The final -2LL value was 1411.46 which is the measure computed after all the predictors have been entered into binary logistic regression. The difference between these two measures is the model $\chi^2$ (1431 – 1411.46 = 19.54) value which is tested for statistical significance. The $\chi^2$ value of 19.54 is statistically significant at $p < 0.01$. Hence it is concluded that significant influence exists between criterion variable and the set of predictor variables.

To check whether multicollinearity condition is within reasonable limits, the values of Variation Inflation Factor (VIF) were examined in Table 6.12. The values in VIF columns in the Table 6.12 shows no values above 10 (Myers, 1990) which indicates multi collinearity is within reasonable limits hence the model can be considered for interpretation.

The Wald statistic' significance column in Table 6.12 shows shift work to be significant at $p < 0.05$. The significance column of Wald statistic in Table 6.12 shows shift work as the significant predictor for MSD pain in shoulder region for annual prevalence among welders in EFC. The Exp (B) column in Table 6.12 shows a value of 1.77 for shift work. The value is considerably greater than one, hence it is concluded that shift work as factor influence MSD pain in shoulder region for annual prevalence among welder employed in EFC.

The inferential Goodness-of-fit Hosmer and Lemeshow test yields a $\chi^2$ (8) value of 5.75 at $p > 0.01$, which is insignificant. This in turn indicates that the model fits the data well and the null hypothesis of a good model fit is acceptable.

Considering the measures discussed above it is concluded that shiftwork as a factor influence annual prevalence of MSD pain in shoulder region for annual prevalence among welders employed in EFC.

### 6.5.3 Elbow region – annual prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in the elbow region among the welders for annual prevalence. The following hypothesis is advanced.

**$H0_{6-12}$:** The personal attributes and employment factors have no influence on annual prevalence of MSD pain in elbow region among the welders in EFC.

To test the null hypothesis $H0_{6-12}$ binary logistic regression was performed. The results are shown in Table 6.13.

**Table 6.13** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in elbow region among welders for annual prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | -.003 | .006 | .250 | 1 | .617 | .997 | .986 | 1.008 |
| Experience | -.005 | .008 | .430 | 1 | .512 | .995 | .979 | 1.011 |
| Working hours | .037 | .151 | .059 | 1 | .807 | 1.037 | .772 | 1.395 |
| Shift work | .046 | .277 | .028 | 1 | .868 | 1.047 | .608 | 1.803 |
| Nature of employment | -.296 | .155 | 3.664 | 1 | .056 | .744 | .549 | 1.007 |
| Mode of apprenticeship training | .237 | .151 | 2.455 | 1 | .117 | 1.267 | .942 | 1.704 |
| Physical work load | -.020 | .050 | .165 | 1 | .685 | .980 | .889 | 1.080 |
| Constant | .274 | .665 | .170 | 1 | .680 | 1.315 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.007Cox and Snell) and (0.010 Nagelkerke), Model $\chi^2$ (7, 1075) = 7.75 p = 0.355.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on elbow region for annual prevalence among welders in EFC. The result ($\chi^2$ (7) = 7.75, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in elbow region among welders in EFC for annual prevalence. Hence, the result supports the null hypothesis $H0_{6\text{-}12}$.

### 6.5.4 Wrist/Hand region – annual prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in the wrist/hand region among the welders for annual prevalence. The following hypothesis is advanced.

**$H0_{6\text{-}13}$:** The personal attributes and employment factors have no influence on annual prevalence of MSD pain in wrist/hand region among the welders in EFC.

To test the null hypothesis $H0_{6\text{-}13}$ binary logistic regression was performed. The results are shown in Table 6.14.

**Table 6.14** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in wrist/hand region among welders for annual prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | .009 | .006 | 2.167 | 1 | .141 | 1.009 | .997 | 1.022 |
| Experience | -.004 | .009 | .182 | 1 | .669 | .996 | .979 | 1.014 |
| Working hours | .087 | .165 | .276 | 1 | .599 | 1.091 | .789 | 1.508 |
| Shift work | -.044 | .305 | .021 | 1 | .885 | .957 | .526 | 1.740 |
| Nature of employment | .059 | .169 | .121 | 1 | .727 | 1.061 | .761 | 1.478 |
| Mode of apprenticeship training | -.049 | .166 | .088 | 1 | .766 | .952 | .688 | 1.318 |
| Physical work load | -.012 | .055 | .049 | 1 | .824 | .988 | .887 | 1.100 |
| Constant | .566 | .730 | .602 | 1 | .438 | 1.761 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.002Cox and Snell) and (0.004 Nagelkerke), Model $\chi^2$ (7, 1075) = 2.66, p = 0.914.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age and experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on wrist/hand region for annual prevalence among welders in EFC. The result ($\chi^2$ (7, 1075) = 2.66, p > 0.01) shows no significant influence of predictor variables on MSD pain in wrist/hand region among welders in EFC for annual prevalence. Hence, the result supports the null hypothesis $H0_{6-13}$.

### 6.5.5 Upper back region – annual prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in the upper back region among the welders for annual prevalence. The following hypothesis is advanced.

**$H0_{6-14}$:** The personal attributes and employment factors have no influence on annual prevalence of MSD pain in upper back region among the welders in EFC.

To test the null hypothesis $H0_{6-14}$ binary logistic regression was performed. The results are shown in Table 6.15.

**Table 6.15** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in upper back region among welders for annual prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | -.007 | .006 | 1.603 | 1 | .206 | .993 | .982 | 1.004 |
| Experience | .010 | .008 | 1.711 | 1 | .191 | 1.011 | .995 | 1.027 |
| Working hours | .012 | .151 | .007 | 1 | .935 | 1.012 | .754 | 1.360 |
| Shift work | .002 | .277 | .000 | 1 | .995 | 1.002 | .582 | 1.723 |
| Nature of employment | -.077 | .154 | .251 | 1 | .616 | .926 | .684 | 1.252 |
| Mode of apprenticeship training | .034 | .151 | .052 | 1 | .820 | 1.035 | .770 | 1.391 |
| Physical work load | -.018 | .050 | .139 | 1 | .710 | .982 | .891 | 1.082 |
| Constant | .181 | .664 | .074 | 1 | .785 | 1.198 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.003Cox and Snell) and (0.002) Nagelkerke), Model $\chi^2$ (7, 1075) = 2.91, p = 0.893.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on upper back region for annual prevalence among welders in EFC. The result ($\chi^2$ (7, 1075) = 2.91, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in the upper back region among welders in EFC for annual prevalence. Hence, the result supports the null hypothesis $H0_{6-14}$.

### 6.5.6 Lower back region – annual prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in lower back region among the welders for annual prevalence. The following hypothesis is advanced.

**$H0_{6-15}$:** The personal attributes and employment factors have no influence on annual prevalence of MSD pain in lower back region among the welders in EFC.

To test the null hypothesis $H0_{6-15}$ binary logistic regression was performed. The results are shown in Table 6.16.

**Table 6.16** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in lower back region among welders for annual prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | .006 | .006 | 1.268 | 1 | .260 | 1.007 | .995 | 1.018 |
| Experience | -.013 | .008 | 2.653 | 1 | .103 | .987 | .972 | 1.003 |
| Working hours | .094 | .151 | .386 | 1 | .534 | 1.098 | .817 | 1.476 |
| Shift work | .050 | .277 | .033 | 1 | .856 | 1.052 | .611 | 1.811 |
| Nature of employment | .162 | .154 | 1.102 | 1 | .294 | 1.176 | .869 | 1.591 |
| Mode of apprenticeship training | -.074 | .151 | .238 | 1 | .626 | .929 | .691 | 1.249 |
| Physical work load | -.003 | .050 | .003 | 1 | .957 | .997 | .905 | 1.099 |
| Constant | -.339 | .664 | .261 | 1 | .609 | .712 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.004 Cox and Snell) and (0.006 Nagelkerke), Model $\chi^2$ (7, 1075) = 4.77, p = 0.688.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on lower back region for annual prevalence among welders in EFC. The result ($\chi^2$ (7, 1075) = 4.77, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in the lower back region among welders in EFC for annual prevalence. Hence, the result supports the null hypothesis $H0_{6\text{-}15}$.

### 6.5.7 Hip/Thigh/Buttock region – annual prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in hip/high/buttock region among the welders for annual prevalence. The following hypothesis is advanced.

**$H0_{6\text{-}16}$:** The personal attributes and employment factors have no influence on annual prevalence of MSD pain in hip/thigh/buttock region among the welders in EFC.

To test the null hypothesis $H0_{6\text{-}16}$ binary logistic regression was performed. The results are shown in Table 6.17.

**Table 6.17** Parameter estimates of multinomial logistic regression for personal attributes and employment factors on MSD pain in hip/thigh/buttock region among welders for annual prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | .007 | .006 | 1.278 | 1 | .258 | 1.007 | .995 | 1.018 |
| Experience | -.005 | .008 | .343 | 1 | .558 | .995 | .980 | 1.011 |
| Working hours | -.180 | .151 | 1.413 | 1 | .235 | .836 | .621 | 1.124 |
| Shift work | .102 | .278 | .134 | 1 | .714 | 1.107 | .642 | 1.908 |
| Nature of employment | .161 | .155 | 1.082 | 1 | .298 | 1.174 | .867 | 1.590 |
| Mode of apprenticeship training | -.076 | .151 | .252 | 1 | .616 | .927 | .689 | 1.247 |
| Physical work load | .080 | .050 | 2.542 | 1 | .111 | 1.083 | .982 | 1.194 |
| Constant | -.416 | .666 | .391 | 1 | .532 | .659 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.006 Cox and Snell) and (0.009) Nagelkerke), Model $\chi^2$ (7, 1075) = 6.89, p = 0.440.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age and experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'hip/thigh/buttock' region for annual prevalence among welders in EFC. The result ($\chi^2$ (7, 1075) = 6.89, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in the hip/thigh/buttock region among welders in EFC for annual prevalence. Hence, the result supports the null hypothesis $H0_{6\text{-}16}$.

### 6.5.8 Knee region – annual prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in knee region among the welders for annual prevalence. The following hypothesis is advanced.

**$H0_{6\text{-}17}$:** The personal attributes and employment factors have no influence on annual prevalence of MSD pain in knee region among the welders in EFC.

To test the null hypothesis $H0_{6\text{-}17}$ binary logistic regression was performed. The results are shown in Table 6.18.

**Table 6.18** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in knee region for annual prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | -.007 | .006 | 1.672 | 1 | .196 | .993 | .981 | 1.004 |
| Experience | .003 | .008 | .143 | 1 | .705 | 1.003 | .987 | 1.019 |
| Working hours | .222 | .151 | 2.162 | 1 | .141 | 1.248 | .929 | 1.678 |
| Shift work | -.005 | .277 | .000 | 1 | .985 | .995 | .578 | 1.713 |
| Nature of employment | -.140 | .154 | .827 | 1 | .363 | .869 | .642 | 1.176 |
| Mode of apprenticeship training | -.063 | .151 | .175 | 1 | .676 | .939 | .699 | 1.262 |
| Physical work load | -.029 | .050 | .348 | 1 | .555 | .971 | .881 | 1.071 |
| Constant | .303 | .665 | .208 | 1 | .648 | 1.354 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.006 Cox and Snell) and (0.008) Nagelkerke), Model $\chi^2$ (7, 1075) = 6.32, p = 0.503.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'knee' region for annual prevalence among welders in EFC. The result ($\chi^2$ (7, 1075) = 6.32, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in the knee region among welders in EFC for annual prevalence. Hence, the result supports the null hypothesis $H0_{6\text{-}17}$.

### 6.5.9 Ankle/Feet region – annual prevalence

This section is on modeling the influence of personal attributes and employment factors on MSD pain in ankles/feet region among the welders for annual prevalence. The following hypothesis is advanced.

**$H0_{6\text{-}18}$:** The personal attributes and employment factors have no influence on annual prevalence of MSD pain in ankle/feet region among the welders in EFC.

To test the null hypothesis $H0_{6\text{-}18}$ binary logistic regression was performed. The results are shown in Table 6.19.

**Table 6.19** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in ankle/feet region among welders for annual prevalence (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | -.005 | .006 | .646 | 1 | .421 | .995 | .984 | 1.007 |
| Experience | -.010 | .008 | 1.692 | 1 | .193 | .990 | .974 | 1.005 |
| Working hours | .261 | .151 | 2.988 | 1 | .084 | 1.299 | .966 | 1.747 |
| Shift work | .148 | .278 | .282 | 1 | .595 | 1.159 | .673 | 1.997 |
| Nature of employment | .163 | .155 | 1.112 | 1 | .292 | 1.177 | .869 | 1.594 |
| Mode of apprenticeship training | -.222 | .151 | 2.157 | 1 | .142 | .801 | .595 | 1.077 |
| Physical work load | -.012 | .050 | .057 | 1 | .811 | .988 | .896 | 1.090 |
| Constant | -.141 | .665 | .045 | 1 | .832 | .869 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.009 Cox and Snell) and (0.012) Nagelkerke), Model $\chi^2$ (7, 1075) = 9.59, p = 0.213.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'ankle/feet' region for annual prevalence among welders in EFC. The result ($\chi^2$ (7, 1075) = 9.59, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in the ankle/feet region among welders in EFC for annual prevalence. Hence, the result supports the null hypothesis $H0_{6\text{-}18}$.

## 6.6 PERSONAL ATTRIBUTES AND EMPLOYMENT FACTORS INFLUENCING MUSCULOSKELETAL DISORDER PAIN AMONG THE WELDER BODY REGION FOR CAUSING ANNUAL DISABILITY

### 6.6.1 Neck region – annual disability

This section is on modeling the influence of personal attributes and employment factors on annual disability caused due to MSD pain in neck region among the welders in EFC. The following hypothesis is advanced.

**$H0_{6\text{-}19}$:** The personal attributes and employment factors have no influence on annual disability caused due to MSD pain in neck region among the welders in EFC.

To test the null hypothesis $H0_{6\text{-}19}$ binary logistic regression was performed. The results are shown in Table 6.20.

**Table 6.20** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in neck region among welders for annual disability (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | | VIF |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper | |
| Age | .006 | .006 | .869 | 1 | .351 | 1.006 | .994 | 1.018 | 1.133 |
| Experience | .008 | .008 | .854 | 1 | .356 | 1.008 | .991 | 1.025 | 1.113 |
| Working hours | .355 | .164 | 4.690 | 1 | .030 | 1.427 | 1.034 | 1.967 | 1.498 |
| Shift work | 1.161 | .290 | 16.013 | 1 | .000 | 3.194 | 1.808 | 5.641 | 4.705 |
| Nature of employment | -.059 | .163 | .130 | 1 | .718 | .943 | .685 | 1.298 | 1.187 |
| Mode of apprenticeship training | .071 | .160 | .195 | 1 | .659 | 1.073 | .784 | 1.468 | 1.321 |
| Physical work load | -.084 | .052 | 2.673 | 1 | .102 | .919 | .831 | 1.017 | 3.427 |
| Constant | -2.332 | .704 | 10.980 | 1 | .001 | .097 | | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.009 Cox and Snell) and (0.012) Nagelkerke), Model $\chi^2$ (7, 1075) = 109.84, p = 0.000.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain that causes annual disability on neck region among welders in EFC. The results of binary logistic regression in Table 6.20 shows $\chi^2$ value of 109.84 significant at $p < 0.01$ which reveals the predictor variables influence MSD pain that causes annual disability in neck region among welders in EFC. Hence, the null hypothesis $H0_{6-19}$ is rejected.

For validating the relationship, initially the Log Likelihood value (-2 Log Likelihood or -2LL) was examined for its significance. In this model the initial -2LL value is 1471 which is the measure of the model with no independent variables, i.e., only with an intercept or a constant. The final -2LL value was 1361.15 which is the measure computed after all the predictors have been entered into binary logistic regression. The difference between these two measures is the model $\chi^2$ (1471 – 1361.15 = 109.84) value which is tested for statistical significance. The $\chi^2$ value of 109.84 is statistically significant at $p < 0.01$. Hence it is concluded that significant influence exists between criterion variable and the set of predictor variables.

To check whether multicollinearity condition is within reasonable limites, the values of Variation Inflation Factor (VIF) were examined in Table 6.20. The values in VIF columns in the Table 6.20 shows no values above 10 (Myers, 1990) which indicates multi collinearity is within reasonable limits and hence the model can be considered for interpretation.

The 'Wald statistic' significance column in Table 6.20 shows shift work to be significant at $p < 0.01$. This shows shift work as the influential predictor for MSD pain in neck region that causes annual disability among welders in EFC. The Exp (B) column in Table 6.20 shows a value of 3.19 for shift work which is considerably greater than one, hence it is concluded that shift work as a factor infuences MSD pain in neck region causing annual disability among welders employed in EFC.

The inferential Goodness-of-fit Hosmer and Lemeshow test yields a $\chi^2$ (8) value of 2.61 at $p > 0 .01$, which is insignificant. This in turn indicates that the model fits the data well and the null hypothesis of a good model fit is acceptable.

Considering the measures discussed it is concluded that shiftwork as a factor influence MSD pain in neck region that causes annual disability among welders employed in EFC.

### 6.6.2 Shoulder – annual disability

This section is on modeling the influence of personal attributes and employment factors on annual disability caused due to MSD pain in shoulder region among the welders in EFC. The following hypothesis is advanced.

**$H0_{6-20}$:** The personal attributes and employment factors have no influence on annual disability caused due to MSD pain in shoulder region among the welders in EFC.

To test the null hypothesis $H0_{6-20}$ binary logistic regression was performed. The results are shown in Table 6.21.

**Table 6.21** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in shoulder region among welders for annual disability (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) Lower | 95% C.I .for Exp (B) Upper | VIF |
|---|---|---|---|---|---|---|---|---|---|
| Age | .009 | .006 | 2.171 | 1 | .141 | 1.009 | .997 | 1.021 | 1.133 |
| Experience | -.007 | .008 | .693 | 1 | .405 | .993 | .977 | 1.010 | 1.113 |
| Working hours | .260 | .162 | 2.566 | 1 | .109 | 1.297 | .944 | 1.781 | 1.498 |
| Shift work | 1.452 | .301 | 23.211 | 1 | .000 | 4.272 | 2.366 | 7.712 | 4.705 |
| Nature of employment | .192 | .165 | 1.346 | 1 | .246 | 1.212 | .876 | 1.676 | 1.187 |
| Mode of apprenticeship training | -.134 | .161 | .698 | 1 | .404 | .874 | .638 | 1.198 | 1.321 |
| Physical work load | .092 | .054 | 2.876 | 1 | .090 | 1.097 | .986 | 1.220 | 3.427 |
| Constant | -3.370 | .728 | 21.430 | 1 | .000 | | | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.158 Cox and Snell) and (0.178 Nagelkerke), Model $\chi^2$ (7, 1075) = 64.39, p = 0.000.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain that causes annual disability on shoulder region among welders in EFC. The results of binary logistic regression in Table 6.21 shows $\chi^2$ value of 64.39 significant at $p < 0.01$ which reveals predictor variables influence MSD pain that causes annual disability in shoulder region among welders in EFC. Hence, the null hypothesis $H0_{6\text{-}20}$ is rejected.

For validating the relationship, initially the Log Likelihood value (-2 Log Likelihood or -2LL) was examined for its significance. In this model the initial -2LL value is 1450 which is the measure of the model with no independent variables, i.e., only with an intercept or a constant. The final -2LL value was 1385.61 which is the measure computed after all the predictors have been entered into binary logistic regression. The difference between these two measures is the model $\chi^2$ (1450 – 1385.61 = 64.39) value which is tested for statistical significance. The $\chi^2$ value of 64.39 is statistically significant at $p < 0.01$. Hence it is concluded that significant influence exists between criterion variable and the set of predictor variables.

To check whether multicollinearity condition is within reasonable limites, the values of Variation Inflation Factor (VIF) were examined in Table 6.21. The values in VIF columns in the Table 6.21 shows no values above 10 (Myers, 1990) which indicates multi collinearity is within reasonable limits hence the model can be considered for interpretation.

The 'Wald statistic' significance column in Table 6.21 shows shift work to be significant at $p < 0.01$. This shows shift work as the influential predictor for MSD pain in shoulder region that causes annual disability among welders in EFC. The Exp (B) column in Table 6.21 shows a value of 4.27 for shift work which is considerably above greater than one and hence it is concluded that shift work as a factor influence MSD pain on shoulder region that causes annual disability among welders employed in EFC.

The inferential Goodness-of-fit Hosmer and Lemeshow test yields a $\chi^2$ (8) value of 5.40 at $p > 0\ .01$, which is insignificant. This in turn indicates that the model fits the data well and the null hypothesis of a good model fit is acceptable.

Considering the measures discussed it is concluded that shiftwork as a factor influence MSD pain in shoulder region that causes annual disability among welders employed in EFC.

### 6.6.3 Elbow region – annual disability

This section is on modeling the influence of personal attributes and employment factors on MSD pain in elbow region causing annual disability among the welders. The following hypothesis is advanced.

**$H0_{6\text{-}21}$:** The personal attribute and employment factor have no influence on MSD pain in elbow region causing annual disability among welders in EFC.

To test the null hypothesis $H0_{6\text{-}21}$ binary logistic regression was performed. The results are shown in Table 6.22.

**Table 6.22** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in elbow region among welders causing annual disability (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | .005 | .006 | .580 | 1 | .446 | 1.005 | .993 | 1.016 |
| Experience | -.003 | .008 | .094 | 1 | .760 | .997 | .981 | 1.014 |
| Working hours | -.136 | .156 | .762 | 1 | .383 | .873 | .643 | 1.185 |
| Shift work | .061 | .285 | .045 | 1 | .831 | 1.063 | .608 | 1.859 |
| Nature of employment | .260 | .163 | 2.554 | 1 | .110 | 1.297 | .943 | 1.783 |
| Mode of apprenticeship training | .122 | .158 | .603 | 1 | .437 | 1.130 | .830 | 1.539 |
| Physical work load | -.024 | .052 | .210 | 1 | .647 | .977 | .883 | 1.081 |
| Constant | -1.051 | .689 | 2.329 | 1 | .127 | .350 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.013 Cox and Snell) and (0.018 Nagelkerke), Model $\chi^2$ (7, 1075) = 14.12, p = 0.068.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on ‘elbow’ region causing annual disability among welders in EFC. The result ($\chi^2$ (7, 1075) = 14.12, $p > 0.01$) shows no significant influence of predictor variables on MSD pain in the elbow region that causes annual disability among welders in EFC. Hence, the result supports the null hypothesis $H0_{6\text{-}21}$.

### 6.6.4 Wrist/Hand region – annual disability

This section is on modeling the influence of personal attributes and employment factors on MSD pain in wrist/hand region causing annual disability among the welders. The following hypothesis is advanced.

**$H0_{6\text{-}22}$:** The personal attributes and employment factors have no influence on MSD pain in wrist/hand region that causes annual disability among welders in EFC.

To test the null hypothesis $H0_{6\text{-}22}$ binary logistic regression was performed. The results are shown in Table 6.23.

**Table 6.23** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in wrist/hand region among welders causing annual disability (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper | VIF |
| Age | .005 | .006 | .724 | 1 | .395 | 1.005 | .993 | 1.017 | 1.133 |
| Experience | -.015 | .008 | 2.977 | 1 | .084 | .986 | .969 | 1.002 | 1.113 |
| Working hours | -.144 | .161 | .802 | 1 | .371 | .866 | .631 | 1.187 | 1.498 |
| Shift work | -.213 | .288 | .548 | 1 | .459 | .808 | .460 | 1.421 | 4.705 |
| Nature of employment | .200 | .164 | 1.492 | 1 | .222 | 1.221 | .886 | 1.683 | 1.187 |
| Mode of apprenticeship training | -.312 | .162 | 3.706 | 1 | .054 | .732 | .533 | 1.006 | 1.321 |
| Physical work load | .122 | .052 | 5.511 | 1 | .019 | 1.130 | 1.020 | 1.251 | 3.427 |
| Constant | .747 | .696 | 1.153 | 1 | .283 | 2.111 | | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.135 Cox and Snell) and (0.127 Nagelkerke), Model $\chi^2$ (7, 1075) = 38.67, p = 0.000.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain that causes annual disability on wrist/hand region among welders in EFC. The results of binary logistic regression in Table 6.23 shows $\chi^2$ value of 38.67 significant at $p < 0.01$ which reveals predictor variables influence MSD pain that causes annual disability in wrist/hand region among welders in EFC. Hence, the null hypothesis $H0_{6\text{-}22}$ is rejected.

For validating the relationship, initially the Log Likelihood value (-2 Log Likelihood or -2LL) was examined for its significance. In this model the initial -2LL value is 1426 which is the measure of the model with no independent variables, i.e., only with an intercept or a constant. The final -2LL value was 1387.33 which is the measure computed after all the predictors have been entered into binary logistic regression. The difference between these two measures is the model $\chi^2$ (1426 – 1387.33 = 38.67) value which is tested for statistical significance. The $\chi^2$ value of 38.67 is statistically significant at $p < 0.01$. Hence it is concluded that significant influence exists between criterion variable and the set of predictor variables.

To check whether multicollinearity condition is within reasonable limites, the values of Variation Inflation Factor (VIF) were examined in Table 6.23. The values in VIF columns in the Table 6.23 shows no values above 10 (Myers, 1990) which indicates multi collinearity is within reasonable limits hence the model can be considered for interpretation.

The ‘Wald statistic’ significance column in Table 6.23 shows physical work load to be significant at $p < 0.05$. This shows physical workload as the influential predictor for MSD pain in wrist/hand region that causes annual disability among welders in EFC. The Exp (B) column in Table 6.23 shows a value of 1.13 which is considerably greater than one and hence it is concluded that physical workload as factor influence influence MSD pain on wrist/hand region that causes annual disability among welders employed in EFC.

The inferential Goodness-of-fit Hosmer and Lemeshow test yields a $\chi^2$ (8) value of 3.51 at $p > 0.01$, which is insignificant. This in turn indicates that the model fits the data well and the null hypothesis of a good model fit is acceptable.

Considering the measures discussed it is concluded that physical workload as a factor influence MSD pain in wrist/hand region that causes annual disability among welders employed in EFC.

**6.6.5 Upper back region – annual disability**

This section is on modeling the influence of personal attributes and employment factors on MSD pain in upper back region causing annual disability among the welders. The following hypothesis is advanced.

**$H0_{6\text{-}23}$:** The personal attributes and employment factors have no influence on MSD pain in upper back region that causes annual disability among welders in EFC.

To test the null hypothesis $H0_{6\text{-}23}$ binary logistic regression was performed. The results are shown in Table 6.24.

**Table 6.24** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in upper back region among welders causing annual disability (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper | VIF |
| Age | -.003 | .006 | .356 | 1 | .551 | .997 | .985 | 1.008 | 1.133 |
| Experience | -.004 | .008 | .199 | 1 | .656 | .996 | .981 | 1.012 | 1.113 |
| Working hours | .037 | .154 | .058 | 1 | .810 | 1.038 | .768 | 1.402 | 1.498 |
| Shift work | 1.111 | .289 | 14.814 | 1 | .000 | 3.036 | 1.725 | 5.346 | 4.705 |
| Nature of employment | -.028 | .157 | .031 | 1 | .860 | .973 | .715 | 1.324 | 1.187 |
| Mode of apprenticeship training | .039 | .154 | .063 | 1 | .802 | 1.039 | .769 | 1.405 | 1.321 |
| Physical work load | .101 | .052 | 3.736 | 1 | .053 | 1.106 | .999 | 1.225 | 3.427 |
| Constant | -1.910 | .689 | 7.696 | 1 | .006 | .148 | | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.132 Cox and Snell) and (0.141)Nagelkerke), Model $\chi 2$ (7, 1075) = 33.24, p = 0.000.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain that causes annual disability in upper back region among welders in EFC. The results of binary logistic regression in Table 6.24 shows $\chi^2$ value of 33.24 significant at $p < 0.01$ which reveals predictor variables influence MSD pain that causes annual disability in upper back region among welders in EFC. Hence, the null hypothesis $H0_{6\text{-}23}$ is rejected.

For validating the relationship, initially the Log Likelihood value (-2 Log Likelihood or -2LL) was examined for its significance. In this model the initial -2LL value is 1477 which is the measure of the model with no independent variables, i.e., only with an intercept or a constant. The final -2LL value was 1443.76 which is the measure computed after all the predictors have been entered into binary logistic regression. The difference between these two measures is the model $\chi^2$ (1477 – 1443.76 = 33.24) value which is tested for statistical significance. The $\chi^2$ value of 33.24 is statistically significant at $p < 0.01$. Hence it is concluded that significant influence exists between criterion variable and the set of predictor variables.

To check whether multicollinearity condition is within reasonable limites, the values of Variation Inflation Factor (VIF) were examined in Table 6.24. The values in VIF columns in the Table 6.24 shows no values are above 10 (Myers, 1990) which indicates multi collinearity is within reasonable limits hence the model can be considered for interpretation.

The 'Wald statistic' significance column in Table 6.24 shows shift work to be significant at $p < 0.01$. This shows shift work as the influential predictor for MSD pain in upper back region that causes annual disability among welders in EFC. The Exp (B) column in Table 6.24 shows a value of 3.03 for the shift work which is considerably greater than one and hence it is concluded that shift work influence MSD pain on upper back region that causes annual disability among welders employed in EFC.

The inferential Goodness-of-fit Hosmer and Lemeshow test yields a $\chi^2$ (8) value of 9.21 at $p > 0.01$, which is insignificant. This in turn indicates that the model fits the data well and the null hypothesis of a good model fit is acceptable.

Considering the measures discussed it is concluded that shiftwork as a factor influence MSD pain in upper back region that causes annual disability among welders employed in EFC.

**6.6.6 Lower back region – annual disability**

This section is on modeling the influence of personal attributes and employment factors on MSD pain in lower back region causing annual disability among the welders. The following hypothesis is advanced.

**$H0_{6\text{-}24}$:** The personal attributes and employment factors have no influence on MSD pain in lower back region that causes annual disability among welders in EFC.

To test the null hypothesis $H0_{6\text{-}24}$ binary logistic regression was performed. The results are shown in Table 6.25.

**Table 6.25** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in lower back region among welders causing annual disability (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) Lower | 95% C.I .for Exp (B) Upper | VIF |
|---|---|---|---|---|---|---|---|---|---|
| Age | -.006 | .009 | .402 | 1 | .526 | .994 | .977 | 1.012 | 1.133 |
| Experience | .004 | .013 | .087 | 1 | .768 | 1.004 | .979 | 1.029 | 1.113 |
| Working hours | .663 | .274 | 5.848 | 1 | .016 | 1.941 | 1.134 | 3.322 | 1.498 |
| Shift work | 5.440 | .707 | 59.251 | 1 | .000 | 230.553 | 57.697 | 921.283 | 4.705 |
| Nature of employment | -.064 | .282 | .051 | 1 | .821 | .938 | .540 | 1.630 | 1.187 |
| Mode of apprenticeship training | .516 | .290 | 3.160 | 1 | .075 | 1.675 | .948 | 2.959 | 1.321 |
| Physical work load | .577 | .132 | 19.097 | 1 | .000 | 1.781 | 1.375 | 2.307 | 3.427 |
| Constant | -12.638 | 1.649 | 58.776 | 1 | .000 | | | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.252 Cox and Snell) and (0.380) Nagelkerke), Model $\chi^2$ (7, 1075) = 312.06, p = 0.000.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age, experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain that causes annual disability in upper back region among welders in EFC. The results of binary logistic regression in Table 6.25 shows $\chi^2$ value of 312.06 significant at $p < 0.01$ which reveals predictor variables influence MSD pain that causes annual disability in lower back region among welders in EFC. Hence, the null hypothesis $H0_{6\text{-}24}$ is rejected.

For validating the relationship, initially the Log Likelihood value (-2 Log Likelihood or -2LL) was examined for its significance. In this model the initial -2LL value is 1164 which is the measure of the model with no independent variables, i.e., only with an intercept or a constant. The final -2LL value was 851.94 which is the measure computed after all the predictors have been entered into binary logistic regression. The difference between these two measures is the model $\chi^2$ (1164 – 851.94 = 312.06) value which is tested for statistical significance. The $\chi^2$ value of 312.06 is statistically significant at $p < 0.01$. Hence it is concluded that significant influence exists between criterion variable and the set of predictor variables.

To check whether multicollinearity condition is within reasonable limites, the values of Variation Inflation Factor (VIF) were examined in Table 6.25. The values in VIF columns in the Table 6.25 shows no values above 10 (Myers, 1990) which indicates multi collinearity is within reasonable limits hence the model can be considered for interpretation.

The 'Wald statistic' significance column in Table 6.25 shows working hours as a factor is significant at $p < 0.05$. While shift work and physical work load as factors are significant at $p < 0.01$. The Exp (B) column in Table 6.25 shows a value of 1.94 for working hours, 230.5 for shift work and 1.78 for physical work load. The values are considerably greater than one and hence it is concluded that working hours, shift work and physical work load influence MSD pain on lower back region that causes annual disability among welders employed in EFC.

The inferential Goodness-of-fit Hosmer and Lemeshow test yields a $\chi^2$ (8) value of 7.63 at $p > 0.01$, which is insignificant. This in turn indicates that the model fits the data well and the null hypothesis of a good model fit is acceptable.

Considering the measures discussed it is concluded that working hours, shiftwork and physical work load as influential factors for MSD pain in lower back region that causes annual disability among welders employed in EFC.

### 6.6.7 Hip/Thigh/Buttock region – annual disability

This section is on modeling the influence of personal attributes and employment factors on MSD pain in hip/thigh/buttock region causing annual disability among the welders. The following hypothesis is advanced.

**$H0_{6\text{-}25}$:** The personal attributes and employment factors have no influence on MSD pain hip/thigh/buttock region that causes annual disability among welders in EFC.

To test the null hypothesis $H0_{6\text{-}25}$ binary logistic regression was performed. The results are shown in Table 6.26.

**Table 6.26** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in hip/thigh/buttock region among welders causing annual disability (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | -.009 | .006 | 2.479 | 1 | .115 | .991 | .980 | 1.002 |
| Experience | .008 | .008 | .923 | 1 | .337 | 1.008 | .992 | 1.024 |
| Working hours | .158 | .153 | 1.061 | 1 | .303 | 1.171 | .867 | 1.580 |
| Shift work | .532 | .280 | 3.610 | 1 | .057 | 1.703 | .983 | 2.948 |
| Nature of employment | .115 | .156 | .542 | 1 | .462 | 1.122 | .826 | 1.525 |
| Mode of apprenticeship training | -.062 | .153 | .163 | 1 | .686 | .940 | .697 | 1.268 |
| Physical work load | .005 | .050 | .011 | 1 | .915 | 1.005 | .911 | 1.109 |
| Constant | -1.017 | .672 | 2.289 | 1 | .130 | .362 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.013 Cox and Snell) and (0.017) Nagelkerke), Model $\chi^2$ (7, 1075) = 13.73, p = 0.056.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age and experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'elbow' region causing annual disability among welders in EFC. The result ($\chi^2$ (7, 1075) = 13.73, $p > 0.01$) in Table 6.26 shows no significant influence of predictor variables on MSD pain in the hip/thigh/buttock region that causes annual disability among welders in EFC. Hence, the result supports the null hypothesis $H0_{6\text{-}25}$.

### 6.6.8 Knee region – annual disability

This section is on modeling the influence of personal attributes and employment factors on MSD pain in knee region causing annual disability among the welders. The following hypothesis is advanced.

**$H0_{6\text{-}26}$:** The personal attributes and employment factors have no influence on MSD pain in knee region that causes annual disability among welders in EFC.

To test the null hypothesis $H0_{6\text{-}26}$ binary logistic regression was performed. The results are shown in Table 6.27.

**Table 6.27** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in knee region among welders causing annual disability (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | .004 | .006 | .467 | 1 | .495 | 1.004 | .993 | 1.015 |
| Experience | -.004 | .008 | .239 | 1 | .625 | .996 | .981 | 1.012 |
| Working hours | -.228 | .151 | 2.281 | 1 | .131 | .796 | .593 | 1.070 |
| Shift work | -.099 | .277 | .128 | 1 | .721 | .906 | .526 | 1.558 |
| Nature of employment | -.157 | .154 | 1.038 | 1 | .308 | .855 | .632 | 1.156 |
| Mode of apprenticeship training | -.045 | .151 | .088 | 1 | .767 | .956 | .712 | 1.285 |
| Physical work load | -.003 | .050 | .005 | 1 | .944 | .997 | .904 | 1.098 |
| Constant | .691 | .664 | 1.082 | 1 | .298 | 1.996 | | |

Note: presence of MSD pain is coded as '1', absence as '0'; (0.004 Cox and Snell) and (0.005) Nagelkerke), Model $\chi^2$ (7, 1075) = 4.15, p = 0.762.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age and experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'knee' region causing annual disability among welders in EFC. The result ($\chi^2$ (7, 1075) = 4.15, $p > 0.01$) in Table 6.27 shows no significant influence of predictor variables on MSD pain in the knee region that causes annual disability among welders in EFC. Hence, the result supports the null hypothesis $H0_{6\text{-}26}$.

### 6.6.9 Ankles/Feet region – annual disability

This section is on modeling the influence of personal attributes and employment factors on MSD pain in ankle/feet region causing annual disability among the welders. The following hypothesis is advanced.

**$H0_{6\text{-}27}$:** The personal attributes and employment factors have no influence on MSD pain in ankle/feet region that causes annual disability among welders in EFC.

To test the null hypothesis $H0_{6\text{-}27}$ binary logistic regression was performed. The results are shown in Table 6.28.

**Table 6.28** Parameter estimates of binary logistic regression for personal attributes and employment factors on MSD pain in ankle/feet region among welders causing annual disability (N=1075)

| Predictors | B | S.E (B) | Wald | df | Sig. | Exp (B) Odds ratio | 95% C.I .for Exp (B) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower | Upper |
| Age | -0.003 | 0.006 | 0.306 | 1 | 0.580 | 0.997 | 0.986 | 1.008 |
| Experience | 0.001 | 0.008 | 0.029 | 1 | 0.865 | 1.001 | 0.986 | 1.017 |
| Working hours | 0.009 | 0.151 | 0.004 | 1 | 0.952 | 1.009 | 0.750 | 1.357 |
| Shift work | 0.345 | 0.279 | 1.533 | 1 | 0.216 | 1.412 | 0.818 | 2.438 |
| Nature of employment | -0.083 | 0.155 | 0.286 | 1 | 0.593 | 0.921 | 0.679 | 1.247 |
| Mode of apprenticeship training | 0.178 | 0.151 | 1.375 | 1 | 0.241 | 1.194 | 0.888 | 1.607 |
| Physical work load | 0.103 | 0.050 | 4.238 | 1 | 0.058 | 1.109 | 1.005 | 1.223 |
| Constant | -0.743 | 0.668 | 1.240 | 1 | 0.266 | 0.476 | | |

Note: presence of MSD pain is coded as '1', absence as '0'. 0.008 (Cox and Snell), 0.009(Nagelkerke), Model $\chi 2$ (7) = 6.46, p = 0.487.

**Interpretation**

Binary logistic regression was modeled to assess whether predictor variables age and experience, working hours, shift work, nature of employment, mode of apprenticeship training and physical workload influence MSD pain on 'ankles/feet' region causing annual disability among welders in EFC. The result ($\chi^2$ (7, 1075) = 6.46, $p > 0.01$) in Table 6.28 shows no significant influence of predictor variables on MSD pain in the ankles/feet region that causes annual disability among welders in EFC. Hence, the result supports the null hypothesis $H0_{6\text{-}27.}$

## 6.7 SUMMARY AND FINDINGS

The summary of binary logistic regression modeling results for personal attributes and employment factors influencing musculoskeletal disorder pain in welders body region are shown in Table 6.29.

**Table 6.29** Summary of binary logistic model results for the influence of personal attributes and employment factors on MSD pain among welders in EFC - Exp (B)(95% CI)

| Body regions | Weekly prevalence | Annual prevalence | Annual disability |
|---|---|---|---|
| Neck | n.s | n.s | shift work 3.19(1.80 – 5.64)* |
| Shoulder | shift work 7 (3.94 -12.64)** | shift work 1.76 (1.02 – 3.06)** | shift work 4.27(2.36 – 7.17)** |
| Elbow | n.s | n.s | n.s |
| Wrist/Hands | n.s | n.s | physical work load 1.13(0.88 -1.68)** |
| Upper back | n.s | n.s | shift work 3.03(1.72 – 5.364)** |
| Lower back | n.s | n.s | working hours 1.94(1.13 – 3.32)* shift work 230 (57.69 -921.28)** physical work load 1.78(1.37 – 2.30)** |
| Hip/Thigh/Buttock | n.s | n.s | n.s |
| Knees | n.s | n.s | n.s |
| Ankles/feet | n.s | n.s | n.s |

**p < 0.01; *p < 0.05; n.s – not significant

- The binary logistic regression modeling results in weekly prevalence column in Table 6.29 shows an Exp(B) value of seven for MSD pain in shoulder. This value is considerably greater than one, which indicates that “shift work” as a factor induces MSD pain in welders’ shoulder region. A finding that can be used as a point for intervention initiatives.
- The binary logistic regression modeling results in annual prevalence column in Table 6.29 shows an Exp(B) value of 1.76 for MSD pain in shoulder region. This value is considerably greater than one which indicates that “shift work” as a factor induces MSD pain in welders’ shoulder region. A finding that can be used as a point for intervention initiatives.
- The binary logistic regression modeling results in annual disability column in Table 6.29 shows an Exp(B) value of 3.19 for neck region. This value is considerably greater than one which indicates that “shift work” as a factor induces MSD pain in welders’ neck region. This MSD pain prevents normal activities thereby inducing disability that causes presenteeism phenomenon during work. A finding that can be used as a point for intervention initiatives.
- The binary logistic regression modeling results in annual disability column in Table 6.29 shows an Exp(B) value of 4.27 for shoulder region. This value is considerably greater than one which indicates that “shift work” as a factor induces MSD pain in welders shoulder region. This MSD pain prevents normal activities thereby inducing disability that causes presenteeism during work. A finding that can be used as a point for intervention initiatives.
- The binary logistic regression modeling results in annual disability column in Table 6.29 shows an Exp(B) value of 1.13 for wrist/hand

region. This value is considerably greater than one which indicates that "physical workload" as a factor induces MSD pain in welders wrist/hands region. This MSD pain prevents normal activities thereby inducing disability that causes presenteeism during work. A finding that can be used as a point for intervention initiatives.

- The binary logistic regression modeling results in annual disability column in Table 6.29 shows an Exp(B) value of 3.03 for MSD pain in upper back region This value is considerably greater than one which indicates that "shift work" as a factor induces MSD pain in welders upper back region. This MSD pain prevents normal activities thereby inducing disability that causes presenteeism during work. A finding that can be used as a point for intervention initiatives.
- The binary logistic regression modeling results in annual disability column in Table 6.29 shows an Exp(B) value of 1.94 for MSD pain in lower back region. This value is considerably greater than one, which indicates that "working hours" as a factor induces MSD pain in welders lower back region. This MSD pain prevents normal activities thereby inducing disability that causes presenteeism during work. A finding that can be used as a point for intervention initiatives.
- The binary logistic regression modeling results in annual disability column in Table 6.29 shows an Exp(B) value of 2.30 for MSD pain in lower back region. This value is considerably greater than one, which indicates that "shift work" as a factor induces MSD pain in welders lower back region. This MSD pain prevents normal activities thereby inducing disability that causes presenteeism during work. A finding that can be used as a point for intervention initiatives.

- The binary logistic regression modeling results in annual disability column in Table 6.29 shows an Exp (B) value of 1.78 for MSD pain in lower back region. This value is considerably greater than one, which indicates that "physical workload" as a factor induces MSD pain in welders lower back region. This MSD pain prevents normal activities thereby inducing disability that causes presenteeism during work. A finding that can be used as a point for intervention initiatives.
- Examining the Table 6.29 Exp (B) value is significant for MSD pain in shoulder region among welders for weekly prevalence, annual prevalence and annual disability. This is a significant finding which is in tune with the findings of Herbert et al. (1976) that manual arc welders are prone for MSD pain in shoulders due to static and dynamic loading during a welding process.
- The employment factors shift work, working hours and physical workload are significant risk factors, which have higher likelihood of inducing musculoskeletal disorder pain among the welders in EFC. These factors can be considered for mitigating MSD pain among welders in EFC for intervention initiatives to address presenteeism phenomenon.

*Chapter* **7**

# SUMMARY AND CONCLUSION

Contents



## 7.1 Introduction

Work injuries are potentially preventable health issues among workers employed in an industrial setting. These work injuries are of two types namely reported and non reported work injuries. Reported work injuries are commonly found in work injury databases. However, non reported work injuries are the ones that cause morbidity, which is suffered in silence by the working communities which deters their efficient productive effort and 'presenteeism' phenomenon. Moreover, for these work injury types, recording system is not in place even in developed countries. Further, review of published literature related to work injuries reveals causal factors that have higher likelihood of influencing work injuries which is based on reported work injuries. Last four decades of research provides indisputable evidence that work injuries are predictable, preventable and treatable.

Flourishing growth in all spheres of human life parallel to technology has isolated work injury research by invisible boundaries that limit scientific advances by limited understanding and collaboration across various branches of study. Going by the work injury complexity, its causation and prevention needs an interdisciplinary approach in work injury studies.

Accident and work injury literature developed for causation models considers only less frequent highly severe work injuries particularly applicable for process industries. However, in the case of manufacturing industries, highly frequent less severe work injuries are critical due to the repetitive nature of the job. Depending on the severity, certain types work injuries with bearable pain are accepted as integral part of work and are not reported. The present study considers highly frequent less severe work injuries, that are treated with first aid or left for self healing, for their influence among welders employed by firms in this engineering fabrication cluster. Published studies indicate work injuries are characteristics of a work place that serves as lead indicators. If these work injuries symptoms are addressed it is expected to bring improvement in work place and hence reduced severe work injuries. Further, factors like personal attributes, employment factors and work factors shows high potential characteristic for work injury risk.

A work system contains many energy interactions between work factor domains. These work factor domains contain many characteristic components that varies across different occupations and industrial settings. Macro ergonomic concepts and approaches consider each work factor domains and its characteristic in the form of energy interactions in a industry specific setting. For a worker employed in injury free work system, the energy interaction between work factor domains and its characteristics should be optimum. Any mismatch in the energy interactions between work factor domains and its characteristic components lead to the work injury. Survey of literature reveals that interactions between personal attribute, employment factors and work factor domain have higher likelihood of causing non reported highly frequent less severe work injuries.

Welding, as a process is potentially hazardous that manifests non reported highly frequent less severe work injuries due to high temperature interactions among welders practicing the trade. Further, these interactions aggravate between different work factors domains due to customized job orders in industrial fabrication environment due to fixed layout facilities. The present study brings forth the personal attributes, employment factors and work factor domains that influence pain frequencies due to non reported highly frequent less severe work injuries and musculoskeletal disorder pain among welders employed in fabrication industry.

## 7.2 RESEARCH CONTRIBUTIONS

The contribution of research work are summarized as follows

- The study identified the gap in the accident and work injury studies through literature survey.
- The study identified the presenteeism phenomenon that is likely to cause morbidity due to non reported highly frequent less severe work injuries among welders. The presenteeism phenomenon has higher likelihood of deteriorating welders effective productive effort.
- Identified personal attributes, employment factors and work factors from literature survey.
- Developed an instrument for measuring welder related non reported highly frequent less severe work injuries, personal attributes, employment factors, welder specific work factor domains with their charteristic items and musculoskeletal disorder pain. The instrument was validated through extensive empirical tests for validity and reliability.
- Practitioners can use the instrument to measure the influence of personal attributes, employment factors, and work factor domains on related non reported highly frequent less severe work injures. Further, the instrument can be used to measure the influence of personal attributes and employment factors on musculoskeletal disorder pain among welders. This could provide as a useful tool to the decision makers for

designing and developing intervention initiatives for alleviating the morbidity among welder for effective productive effort in fabrication industries.

- The pain frequencies due to non reported highly frequent less severe work injuries are different between welder population employed by firms in engineering fabrication cluster and welders employed by organised and unorganised sector fabrication firms.
- Age significantly influences pain frequencies due to non reported highly frequent less severe work injuries among welder population employed in engineering fabrication cluster. The result contradicts the findings of no relation between age and work injury in work injury literature.
- Middle age group welders are associated with higher levels of non reported highly frequent less severe work injuries. This finding contradicts the literature finding that young workers below 25 years are more likely to be injured during work.
- The age influencing pain frequencies due to non reported highly frequent less severe work injuries are significant among the welder population employed in engineering fabrication cluster. But, the relationship is insignificant among the welders employed by organised and unorganised sector fabrication firms. This finding that supports the inconclusiveness of age and work injury relationship in work injury literature.
- Experience of the welder has no significant influence on non reported highly frequent less severe work injuries among welders.
- Welders employed in extended working hours experience more pain frequencies due to non reported highly frequent less severe work

injuries. This finding is in tune with literature finding of increased work injury risk during extended working hours. The result is significant for the welder population and insignificant for the welders employed by organised sector firms. This finding indicates an inconclusiveness of increased work injury risk among welders employed in extended working hours.

- Shift work significantly influences pain frequencies due to non reported highly frequent less severe work injuries among welders in EFC population, which is in tune with the literature findings of increased work injury risk due to shift work.
- Nature of employment (regular and adhoc/contract) influence pain frequencies due to non reported highly frequent less severe work injuries. This finding is in tune with the literature findings that welders employed in contract/adhoc basis experience more work injuries.
- Mode of apprenticeship influences pain frequencies due to non reported highly frequent less severe work injuries. Welders who had acquired trade knowledge through on-the-job-training methods experience more pain frequencies. This finding supports the literature finding that welders who lack institutional training, experience increased work injury risk.
- Welders who executed low mean physical workload experience more pain frequencies due to non reported highly frequent less severe work injuries. This result is significant among welder population employed in engineering fabrication cluster and welders employed by unorganised sector fabrication firms. However, the result is not significant among the welders employed by organised sector firms. This significant finding contradicts higher physical workload as the cause of work injuries.

- Identified shift work as a factor, which influence musculoskeletal disorder pain, which is commonly prevalent in shoulder region among the welder population. This pain can continue and cause disability by preventing welders in doing their normal activities. This in turn promotes presenteeism phenomenon among welder population that leads to reduced productive effort during work.
- Identified shift work as a factor that influences musculoskeletal disorder pain in neck, upper and lower back regions among welders, which prevents them from doing their normal activities, which reflect in the form of morbidity in their work place. This morbidity induced by shift work promotes presenteeism phenomenon among welder population leading to reduced productive effort during work.
- Identified physical workload as the factor that influences musculoskeletal disorder pain in wrist/hand regions among welders which prevents normal activities. This morbidity induced by physical workload promotes presenteeism phenomenon among welder population leading to deteriorated productive effort during work.
- Identified working hours as the factor, which influences musculoskeletal disorder pain on lower back regions among welders by preventing normal activities. This morbidity induced by working hours promotes presenteeism phenomenon among welder population leading to deteriorated productive effort during work.

## 7.3 LIMITATIONS OF THE PRESENT WORK

Published literatures on the factors influencing welder work injuries are scarce. The available literature on welder work injuries are based on epidemiological studies, which are based on reported injuries. The factors that influence work injuries are identified from accident and work injury literature, which are based on reported injury episodes. This can be considered as a limitation of the study. The injury data was collected from the respondent using a questionnaire .There is no means of recording work injuries treated with first aid for inter observable reference in the work place hence the reliability of the response is a matter of concern and can be considered as another limitation of the study. Many times the survey was looked upon by the respondents with apprehensions as they feared it might interfere with sustainability of their job, this may have some bias in the survey response hence considered as limitation of the study. The seasonal business cycle promotes welder recruitment on adhoc/contract basis this recruitment may have a bearing on the true responses and can serve as limitation for the study.

### 7.4 SCOPE FOR FUTURE WORK

This work is an attempt to study the influence of personal attributes, employment factors and work factors on non reported work injuries. Majority of the accident models and work injury studies are related to process industries where accident/injuries are of less frequent highly severe in nature. Generally, the job characteristic in a manufacturing environment is of repetitive and highly frequent less severe in its character which is likely to cause work injuries that interferes with workers productive effort. An immediate need that has to be addressed is to prevent acute and chronic work injuries influenced by the personal attributes, employment factors, work factors and musculoskeletal disorders. This work identifies the acute and chronic nature of work injuries and its influential factors that demonstrate the research ability and usefulness of this important area of research. The emphasis was given to manufacturing units in this research for the reasons stated. The survey instrument developed can also be extended to other manufacturing areas to capture the factors that influence non reported work injuries which can be targeted for intervention initiatives

## 7.5 CONCLUSION OF THE THESIS

- Age significantly influences pain frequencies due to non reported highly frequent less severe work injuries among welders employed in fabrication industry.
- Experience is not significant in influencing pain frequencies due to non reported highly frequent less severe work injuries among welders employed in fabrication firms.
- Working hours influence pain frequencies due to non reported highly frequent less severe work injuries among welders employed by fabrication firms.
- Shift work influences pain frequencies due to non reported highly frequent less severe work injuries among welders employed in fabrication firms.
- Lower physical workload significantly influences pain frequencies due to non reported highly frequent less severe work injuries among welders employed by fabrication firms.
- Nature of employment influences pain frequencies due to non reported highly frequent less severe work injuries among welders employed by fabrication firms.
- Mode of apprenticeship training influences pain frequencies due to non reported highly frequent less severe work injuries among welders employed by fabrication firms.

- Health perception, safety culture and social environment work factor domains predict pain frequencies due to non reported highly frequent less severe work injuries among welders employed in engineering fabrication cluster.
- Shift work, working hours and physical workload influence musculoskeletal disorder pain among welders causing morbidity that promotes presenteeism reflected in the form of reduced productive effort among welders employed in fabrication firms.

The above identified body regions along with their influencing factors can be used for directing interventions to alleviate MSD pain. Further, these results can used for work intervention studies to reduce pain due to MSD injuries.

# REFERENCES


[1] Adelani, T., Adewale, A., Oladeji, Y., Aderemi, D., 2014. Assessment of the use of safety devices by welders in Osogbo, Nigeria. International Journal of Recent Scientific Research (5) 2, 397-402.

[2] Andriessen, J., 1978. Safe behavior and safety motivation. Journal of Occupational Accidents 1, 363–376.

[3] Anne, M. F., Ann,W., 2004. Occupational injuries. Taylor and Francis e library.

[4] Anuradha, C., Tanu, A., Jugal, K., Tor, E.D., Gopal, K. I., 2014. Occupational hazard exposure and general health profile of welders in rural Delhi. International Journal of Recent Scientific Research 18(1), 397-402.

[5] Aronsson, G., Gustafsson, K., Dallner, M., 2000. Sick but yet at work. An empirical study of sickness presenteeism, Journal of Epidemiology and Community Health 7, 502–509.

[6] Arunraj, N., Maiti, J., 2007. Risk-based maintenance: techniques and applications. Journal of Hazardous Materials 142, 653–661.

[7] Askildsen, J.E.E., Bratberg, A., Nilsen, S., 2005. Unemployment, labor force composition and sickness absence: A panel study. Health Economics 14(11), 1087–1101.

[8] Axelsson, J., Kecklund, G., Åkerstedt, T., Lowden, A.,1998. Effects of alternating 8- and 12-hour shifts on sleep, sleepiness, physical effort and performance. Scandinavian. Journal Work Environment and Health 24, 62–68.

[9] Bahr, N., 1997. System safety engineering and risk assessment – A practical approach. Taylor and Francis, Washington DC.

[10] Bailer, A., Reed, L., Stayner, L., 1997. Modeling fatal injury rates using poisson regression: a case study of workers in agriculture, forestry, and fishing. Journal of Safety Research 28, 177–186.

[11] Bajpayee, T., Rehak, T., Mowrey, G., Ingram, D., 2004. Blasting injuries in surface mining with emphasis on flyrock and blast area security. Journal of Safety Research 35, 47–57.

[12] Baker, K., Olson, J., Morisseau, D., 1994. Work practice, fatigue and nuclear power plant and safety performance. Human Factors 36, 244 – 57.

[13] Bambergr, P., Biron, M., 2007. Group norms and excessive absenteeism: the role of peer referent others. Organization Behaviour and Human Decision Process 103, 179-196.

[14] Banerjee, S,R., 1993. Agricultural child labor in West Bengal. Indian Pediatrics 30, 1425-9.

[15] Basha, S., Maiti, J., 2012. Relationships of demographic factors, job risk perception and work injury in a steel plant in India Safety Science 51, 374-81.

[16] Bennett, J., Passmore, D., 1984a. Correlates of coalmine accidents and injuries: a literature review. Accident Analysis and Prevention 16, 37–45.

[17] Bentler, P.M., Bonett, D.G., 1980. Significance test and goodness of fit in the analysis of covariance structures. Psychological Bulletin 88, 588-606.

[18] Biji, C., Jisha, T., Lakshmy, P., Praseetha, P, C., Rehnas Beegum, M., Remya, B., Safeena, B., Sindu, P., Sruthi, M., 2013. Occupational health hazards in welders of palakkad district: an appraisal. Indian Journal of Public Health and Research Development 4, 49-53.

[19] Blank, V., Laflamme, L., Diderichsen, F., 1996. The impact of major transformations of a production process on age-related accident risks: a study of an iron ore mine. Accident Analysis and Prevention 28, 627–636.

[20] Blunt, J., Balchin, N., 2005. Health and safety in welding and allied processes. Cambridge: Wood head, Second eds, pp.252.

[21] Bohrnstedt, G., Rossi, P., Wright, J., Anderson, A. 1983. A handbook of survey research, Academy Press, San Diego, CA.

[22] Boles, M., Pelletier, B., Lynch, W.D., 2004. The relationship between health risks and work productivity. Journal of Occupational and Environmental Medicine 46, 737–745.

[23] Bowerman, B., O'Conell, R,T., 1990. Linear statistical models: An applied approach, Second eds, Belmont, C.A: Duxbury.

[24] Boyd, A., Radson, D., 1999. Statistical analysis of injury severity rates. IIE Transactions 31, 207–216.

[25] Breslin, F.C., Pole, J.D., Tompa, E., Amick, B.C., Smith, P., Johnson, S.H., 2007.Antecedents of work disability absence among young people: a prospective study. Annals of Epidemiology 17, 814–820.

[26] Brown, R.L., Holmes, H., 1986. The use of a factor analytic procedure for assessing the validity of an employee safety climate model. Accident Analysis and Prevention 18, 455-470.

[27] Burton, W.N., Conti, D.J., Chen, C.Y., Schultz, A.B., Edington, D.W., 1999. The role of health risk factors and disease on worker productivity. Journal of Occupational and Environmental Medicine. 41, 863–877.

[28] Butani, S., 1988. Relative risk analysis of injuries in coal mining by age and experience at present company. Journal of Occupational Accidents 10, 209–216.

[29] Canadian centre of occupational health and safety (CCOHS), 2011. Welding radiation and the effects on eyes and skin. www.ccohs.co/ safety. Retrieved 14 April 2014.

[30] Carmines, E.G., Zeller, R.A., 1990. Reliability and validity assessment, Sage Publications, USA.

[31] Central statistical organization 2002. Select socioeconomic statistics of India. New Delhi: Ministry of Statistics and Programme Implementation, Government of India.

[32] Chang, W., 2004. A statistical model to estimate the probability of slip and fall incidents. Safety Science 42, 779–789.

[33] Clarice A. B., 2013. Scientific literature on welding apprentices and preventive medicine: An integrative literature review- open journal of preventive medicine. Open Journal of Preventive Medicine 9, 543-550.

[34] Cohen, J. 1988. Statistical power and analysis for the behavioral sciences, second eds. Hillsdale, NJ: Lawrence Erlbaum Associates.

[35] Coleman, P., Kerkering, J., 2007. Measuring mining safety with injury statistics: lost workdays as indicators of risk. Journal of Safety Research 38, 523–533.

[36] Cooper, M.D., Phillips, R.A., 2004. Exploratory analysis of the safety climate and safety behaviour relationship. Journal of Safety Research 35, 497–512.

[37] Costa, L., 2009. Health and safety in fabrication and repair of welded components: aspects, impacts and compliance with regulations, IIW commission VIII. Health and Safety environment 28-35.

[38] Cox, T., Cox, S., 1992, Occupational health: past, present and future. Work and Stress 6, 99–102.

[39] Cox, T., Cox, S., 1993, Psycho social and organizational hazards at work, European Occupational Health Series No. 5, Copenhagen: WHO Regional Office Europe.

[40] Cronbach, L.J., 1951. Coefficient alpha and the internal structures of tests. Psychometrika 16, 297-334.

[41] CSR perceptions and activities of small and medium enterprises (SMES) in seven geographical clusters survey report (2008). Vienna: United Nations Industrial Development Organization.

[42] Cuny, X., Lejeune, M., 1999. Occupational risks and the value and modelling of a measurement of severity. Safety Science 31, 213–229.

[43] David, G., Woods, V., Li, G., Buckle, P., 2008. The development of the Quick Exposure Check (QEC) for assessing exposure to risk factors for work-related musculoskeletal disorders. Applied Ergonomics 39, 57–69.

[44] Davies, J., Kemp, G., Frostick, S., McElwaine, C.D.J., 2003. Manual handling injuries and long term disability. Safety Science 41, 611–625.

[45] Dickinson, C. E., Campion, K., Foster, A. F., Newman, S. J., O, Rourke, A. M.T., Thomas, P.G., 1992. Questionnaire development: an examination Nordic Musculoskeletal Questionnaire. Applied Ergonomics 13(3), 19 – 24.

[46] Duchon, J.C., Smith T.J., Keran, C.M., Koehler, E.J, 1997. Psycho physiological manifestations of performance during work on extended work shifts. International Journal of Industrial Ergonomics 20(1):39–49.

[47] Duzgun, M.A., Einstein, H., 2004. Assessment and management of roof fall risks in underground coal mines. Safety Science 42, 23–41.

[48] Ebrahimi, H,, Kazemi, R., Mohammadbeigi, A., 2011. Comparative survey of work related musculoskeletal disorders (WRMDs) prevalence and related factors in Iranian welders. Pakistan Journal of Medical Science 27(2), 282-285.

[49] Ekpo, A.H., The informal sector 2012. Retrieved from http://www.online Nigeria.com on February 25, 2012.

[50] Erdal S, Berman L. Occupational exposure environment, risk factors and hazards awareness of metal sculptors and artist welders in the U.S. 2008. Retrieved from http://www.cieh.org on September 06, 2012.

[51] Ferguson, J., McNally, M., Booth, R., 1984. Individual characteristics as predictors of accidental injuries in naval personnel. Accident Analysis and Prevention 16, 55–62.

[52] Ferguson, J., McNally, M., Booth, R., 1985. Accidental injuries among naval personnel by occupation, duty status, and pay-grade. Accident Analysis and Prevention 17, 79–86.

[53] Ferry, T., 1988. Modern accident investigation and analysis. Wiley, New York

[54] Fotta, B., Bockosh, G., 2000. The aging workforce: an emerging issue in the mining industry.

[55] Franceschini, F., Galetto, M., 2001. A new approach for evaluation of risk priorities of failure modes in FMEA. International Journal of Production Research 39, 2991–3002.

[56] Frank, A., 2000. Injuries related to shift work. American Journal of Preventive Medicine 18, 33–36.

[57] Gander, P., Merry, A., Miller, M., 2000. Hours of work and fatigue related error: A survey of New Zealand anesthetists, Anesthetists Intensive Care 28, 178 – 83.

[58] Ganesh, K., Priya, D., 2014. Prevalence and pattern of occupational injuries at workplace among welders in coastal south India. Indian Journal Occupational and Environmental Medicine 18 (3), 135-139.

[59] Gautam, A,K., Yunus, M., Rahman., A., Reddy, S.S., 2003. Environmental monitoring of asbestos products manufacturing units-a case study. Indian

[60] Genaidy, A., Waldemar, K., Paul Succop, Young-Guk Kwon, Ahemed Alhemoud, Dev Goyal., 2000. A classification system for characterization of physical and non physical factors, International Journal of Occupational Safety And Ergonomics 6 (4), 535 -548.

[61] Gerbing, D.W., Anderson, J.C., 1988. An updated paradigm for scale development incorporating unidimensionality and its assessment. Journal of marketing Research 25, 186-192

[62] Ghosh, S,K., Parikh, J,R., Gokani, V,N., Kashyap, S,K., Chatterjee, S,K., 1979. Studies on occupational health problems during agricultural operation of Indian tobacco workers: A preliminary survey report. Journal of Occupational Medicine 21, 45-7.

[63] Gillen, M., Baltz, D., Gassel, M., Kirsch, L., Vaccaro, D., 2002. Perceived safety climate, job demands, and co-worker support among union and nonunion injured construction workers. Journal of Safety Research 33, 33–51.

[64] Greenwood, M., Woods, H., 1919. The incidence of industrial accidents upon individuals with special reference to multiple accidents. Tech. rep., Industrial Fatigue Research Board, London.

[65] Grinyer, A., Singleton, V., 2000. Sickness absence as risk-taking behaviour: a study of organisational and cultural factors in the public sector. Health, Risk and Society, 2, 7–21.

[66] Guastello, D., Guastello, S., 1987. The relationship between work group size and occupational accidents. Journal of Occupational Accidents 9, 1–9.

[67] Gun, R., Ryan, C., 1994. A case-control study of possible risk factors in the causation of occupational injury. Safety Science 18, 1–13.

[68] Gupta,B,N., Mathur, N., Rastogi, S,K., Srivastava, A,K., Chandra, H., Pangtey, B.S., 1995. Socio-economic, environmental and health aspects of farm workers engaged in mango plantations. Biomed Environ Science, 8:301-9.

[69] Gururaj, G., 2005. Injuries in India: A national perspective, National Commission on Macroeconomics and Health report, pp.365 -368.

[70] Haddon, W., Suchman, E., Klein, D., 1964. Accident research: methods and approaches. Harper and ROW, New York.

[71] Hair, I. F., Anderson, R.E., Tatham, R.L., Black, W.C., 1998. Multivariate data analysis, Prentice-Hall International, New Jersey, USA.

[72] Hale, A., Hale, M., 1972. A review of the industrial accident research literature. Technical representation. Her Majesty's Stationery Office, London.

[73] Hamel, K., Welding safety details. Retrieved from http://www.arc. welding_ and beyond.com/weld on November 21, 2011.

[74] Harel, Y., Overpeck, M. D., Jones, D. H.,. 1994. The effects of recall on estimating annual nonfatal injury rates for children and adolescents. American Journal of Public Health, 84 , 599–605.

[75] Harms, R.L., 1993. Safety Analysis: Principles and practice in occupational safety. Elsevier Applied Science, London.

[76] Haslam, R., Hide, S., Gibb, A., Gyi, D., Pavitt, T., Atkinson, S., Duff, A., 2005. Contributing factors in construction accidents. Applied Ergonomics 36, 401–415.

[77] Hassan, M,A., Khan. Z., Yunus, M., Bhargava, R., 2002. Health profile of lock factory workers in Aligarh. Indian Journal Public Health 46, 39-45.

[78] Heinrich, H., 1932. Industrial accident prevention, first ed. McGraw Hill, New York.

[79] Heinrich, H., Petersen, D., Ross, N., 1980. Industrial Accident Prevention, McGraw-Hill, New York.

[80] Hemp, P., 2004. Presenteeism: at work - but out of it, Harvard Business Review 82(10), 49–58.

[81] Hendrick, H., 1986. Macroergonomics as a preventive strategy in occupational health: an organizational level approach. In: Hendrick, H., Bradley, G. (Eds.), Human Factors in Organizational Design and Management II. Elsevier Science.

[82] Henley, E., Kumamoto, H., 1981. Reliability engineering and risk assessment. Prentice-Hall Inc, New Jersey

[83] Herberts, P. Kadefors, R., Peters, C., 1976 Muscular reaction to welding work: an electromyographic investigation. Ergonomics 19, 543-558.

[84] Hewitt, P., 1996. Occupational health in metal arc welding, Indoor Built Environment 5(1), 253 -262.

[85] Hital, R, M., 2008. Safety and occupational health: Challenges and opportunities in emerging economies. Indian Journal of Occupational Environmental Medicine 12, 3-9.

[86] HS04 – 044A, 2012. Department of insurance. Texas, United States

[87] ICECI, 2004. International classification of external causes of injuries. ICECI Coordination and Maintenance Group, World Health Organization.

[88] Iman,A., 2004. Occupational health research in developing countries: A partner for social justice. American Journal of Public Health 94 (11), 1916-1921.

[89] International Labour Organization Annual Report., 2013, Geneva.

[90] Jeong, B., 1999. Comparisons of variables between fatal and nonfatal accidents in manufacturing industry. International Journal of Industrial Ergonomics 23, 565–572.

[91] Johnson, W., 1980. MORT safety assurance systems. National Safety Council, New York.

[92] Josephine, A., Engels., Joost, W.J Vander ., Theo F Senden., Bep van't Hof., 1996. Work related risk factors for musculoskeletal complaints in the nursing profession: results of a questionnaire survey. Occupational and Environmental Medicine 53, 636-64.

[93] Joshi, S,K., Sharma, U., Sharma, P., Pathak, S,S., Sitaraman, S., Verma, C,R., 1994. Health status of carpet weaving children. Indian Pediatrics 31, 571-4.

[94] Jovanovic, J., Arand-elovic, M., Jovanovic, M., 2004. Multidisciplinary aspects of occupational accidents and injuries. Facta Univ. Ser.: Working Living Environment Protection. 2 (4), 325–333.

[95] Kadefor, R., Peters, C., Herbert, P. 1976 Muscular reaction to welding work: an electro myographic investigation. Ergonomics 19: 543-558.

[96] Kadefors, R., Laring., Jonas., 1997. Ergonomics and welding workplace design. In: Brune, D. (Ed.) The Workplace, Volume 2: Major Industries and Occupations. Geneva: ILO, p. 478 – 490.

[97] Kahya, E., 2009. The effect of job performance on effectiveness. International Journal of Industrial Ergonomics. 39, 96-104.

[98] Kaplan, R. M., Scauzzo, D. P., 1993. Psychological testing: Principles, applications and issues, Pacific Grove, CA.

[99] Karwowski. W., 2006, International encyclopaedia of ergonomics and human factors, Second edition, CRC ,Taylor and Francis

[100] Kee, D., Karwowski, W., 2001. LUBA: an assessment technique for postural loading on the upper body based on joint motion discomfort and maximum holding time. Applied Ergonomics 32, 357–366.

[101] Kejriwal, B., 2002. Safety in mines: A survey of accidents, their causes and prevention. Lovely Prakashan, Dhanbad.

[102] Keyserling, W., 1983. Occupational injuries and work experience. Journal of Safety Research 14, 37–42.

[103] Khan, F., Amyotte, P., Mattia, D., 2006. HEPI: a new tool for human error probability calculation for offshore operation. Safety Science 44, 313–334.

[104] Khanzode, V., Maiti, J., Ray, P., 2011. A methodology for evaluation and monitoring of recurring hazards in underground coal mines. Safety Science 49, 1172–1179.

[105] Khanzode, V.V., Maiti, J., Ray, and P.K., 2012. Occupational injury and accident research: a comprehensive review. Safety Science 50, 1355–1367.

[106] Kirwan, B., 1990. A practical ergonomics methodology. In: Wilson, J., Corlett, E (Eds.), Human Reliability Assessment. Taylor and Francis, London.

[107] Kjellen, U., 1984a. The deviation concept in occupational accident control definitions and classification. Accident Analysis and Prevention 16, 289–306.

[108] Kjellen, U., 1984b. The deviation concept in occupational accident control – II: data collection and assessment of significance. Accident Analysis and Prevention 16,

[109] Kjellen, U., 1984c. The role of deviations in accident causation and control. Journal of Occupational Accidents 6, 117–126.

[110] Kjellen, U., 1995. Integrating analyses of the risk of occupational accidents into the design process – part II: method for prediction of the LTI-rate. Safety Science 19, 3–18.

[111] Kjellen, U., Hovden, J., 1993. Reducing risks by deviation control – a retrospection into a research strategy. Safety Science 16, 417–438.

[112] Kjellen, U., Larsson, T., 1981. Investigating accidents and reducing risks- a dynamic approach. Journal of Occupational Accidents 3, 129–140.

[113] Kjellen, U., Sklet, S., 1995. Integrating analyses of the risk of occupational accidents into the design process – part I: a review of types of acceptance criteria and risk analysis methods. Safety Science 18, 215–227.

[114] Kumamoto, H., Henley, E., 1996. Probabilistic risk assessment and management fore and scientists, second ed. IEEE Press.

[115] Laamme, L, Menckel, E., 1995. Aging and occupational accidents: a review of the literature of the last three decades. Safety Science 21, 145–161.

[116] Langley, J., 1988. The need to discontinue the use of the term ‘‘accident’’ when referring to unintentional injury events. Accident Analysis and Prevention 20,1–8.

[117] Lauridsen, O., Tonnesen, T., 1990. Injuries related to the aspects of shift working - a comparison of different offshore shift arrangements. Journal of Occupational Accidents 12, 167-76.

[118] Lees, F., 1980. Loss prevention in the process Industries. Butterworth and Co Ltd, London.

[119] Leigh, J., Mulder, H., Want, G., Farnsworth, N., Morgan, G., 1990. Personal and environmental factors in coal mining accidents. Journal of Occupational Accidents 13, 233–250.

[120] Levin, L., Oler, J., Whiteside, J., 1985. Injury incident rates in a paint company on rotating production shifts. Accident Analysis and Prevention 17, 67–73.

[121] Lindell, M., 1997. Occupational safety and health inspection scores predict rates of workers' lost time injuries. Accident Analysis and Prevention 29, 563–571.

[122] Loeppke R, Taitel M, Haufle V, Parry T, Kessler RC, Jinnett K, 2007. "Health and productivity as a business strategy: A multi-employer study," Journal of Occupational Environmental Medicine 51(4), 411–428.

[123] Lowery, J., Borgerding, J., Zhen, B., 1998. Risk factors for injury among construction workers at Denver, International airport. American Journal of Industrial Medicine 28, 178 – 83.

[124] Lozada, A., Larsen, S., Laughery, K., 1987. Do identical circumstances precede minor and major injuries? In: Rising to New Heights with Technology, vol. 1. Human Factors Society, New York, 200–204.

[125] Macias, D, J., Hafner, J., Brilllmen, J, C., 1996. Effect of time of day and duration into shift on hazardous exposure to biological fluid. Academia of Emerging Medicine 3, 605-10.

[126] Maiti, J., 2005. Risk assessment and safety evaluation of mining system. Journal of Institution of Engineers (India) – Mining 85, 33–41.

[127] Maiti, J., Bhattacherjee, A., 1999. Evaluation of risk of occupational injuries among underground coal mine workers through multinomial logit analysis. Journal of Safety Research 30, 93–101.

[128] Maiti, J., Bhattacherjee, A., Bangdiwala, S., 2001. Loglinear model for analysis of cross-tabulated coal mine injury data. Injury Control and Safety Promotion 8, 229–236.

[129] Maiti, J., Chatterjee, S., Bangdiwala, S., 2004. Determinants of work injuries in mines: an application of structural equation modeling. Injury Control and Injury Control and Safety Promotion 11, 29–37.

[130] Maiti, J., Khanzode, V., 2009. Development of a relative risk model for roof and side fall fatal accidents in underground coal mines in India. Safety Science 47, 1068–1076.

[131] Maiti, J., Khanzode, V., 2009. Development of a relative risk model for roof and side fall fatal accidents in underground coal mines in India. Safety Science 47, 1068- 1076.

[132] Malhotra P, Dhar S, Dogra S, Kaul S, Raina RK., 1995. Pattern of injuries in hydro electric project. Journal of the Indian Medical Association 1995; 5:171–2.

[133] Marta R.C.V., Clarice A.B., Laurelize P. R., Marlise C., 2012. Risk communication as a tool for training apprentice welders: A study about risk perception and occupational accidents. The Scientific World Journal. doi:10. 1100/2012/140564.

[134] Martin A. Makary., Ali A.A., Christine G. Holzmueller, Bryan Sexton, J., Dora Syin, B.S., Marta M. Gilson., Mark S. Sulkowski, Peter J. Pronovost., 2007. Needle stick injuries among surgeons in training. The New England Journal of Medicine. doi: 10.1056/ NEJMoa070378

[135] Mathews, R., Reis, C., Iacopino, V., 2003. Child labor: A matter of health and human rights. Journal of Ambulatory Care and Management 26, 181-2.

[136] Mathur, N., Sharma, K., 1988. Medico-economic implication of industrial hand injuries in India. The Journal of Hand Surgery 3, 325–7.

[137] Mcartt, A., Rohrbarg, J., Hammer, L., 2000. Factors with falling asleep at wheel among long distance truck drivers. Accident Analysis and Prevention 32, 493-504.

[138] McAtamney, L., Corlett, E., 1993. RULA: a survey method for the investigation of work-related upper limb disorders. Applied Ergonomics 24, 91–99.

[139] McKenna, F., 1983. Accident proneness: a conceptual analysis. Accident Analysis and Prevention 15, 65–71.

[140] McKevitt, C., Morgan, M., Dundas, R., Holland, W., 1997. Sickness absence and 'working through' illness: a comparison of two professional groups, Journal of Public Health Medicine, 19, 295–300.

[141] McLeod, R., Stockwell, T., Rooney, R., Stevens, M., Phillips, M., Jelinek, G., 2003. The influence of extrinsic and intrinsic risk factors on the probability of sustaining an injury. Accident Analysis and Prevention 35, 71–80.

[142] Ministry of labour and employment report (MoL, 2012)

[143] Mitchell, C., Cloeren, M., Schwartz, B., 1993. Application of an injury surveillance system to injuries at an industrial facility. Accident Analysis and Prevention 25,453–458.

[144] Mitra, S., 1993. A study of the health conditions of child workers in a small scale leather industry in Calcutta. Branch Journal of Indian Medical Association 50, 938-40.

[145] Mitra, S., 1994. Factors in the socio-cultural environment of child labourers: A study in a small scale leather goods industry in Calcutta. Occupational and Environment Medicine 51, 822-5.

[146] Mock, C., Acheampong, F., Adjei, S., 1999. The effect of recall on estimation of incidence rates for injury in Ghana. International Journal of Epidemiology, 28, 750–755.

[147] Moulin, J.J., Portefaix, P., Wild, P., Mur, J, M., Smagghe, G., Mantout, B., 1997: Mortality study among workers producing ferroalloys and stainless steel in France. Journal of Industrial Medicine 47 (2), 537-543.

[148] Mullen, J., 2004. Investigating factors that influence individual safety behavior at work. Journal of Safety Research 35, 275–285.

[149] Murlidhar, V., Murlidhar, V,J., Kanhere, V., 1995. Byssinosis in a Bombay textile mill. National Medical Journal of India 8, 204-7.

[150] Myers, R. 1990. Classical and modern regression with applications, Second edition, Boston, MA: Duxbury.

[151] Nag, P,K,, Nag, A., 2004. Drudgery, accidents and injuries in Indian agriculture. Indian Health 42, 149-62.

[152] Nasibeh Azdeh Fard., Anna Scuuh., Ehsan Rashedi., Jaime Camello, S., 2015. Risk assessment of occupational injuries using accident severity grading Safety Science 76, 160 -167.

[153] National Commission on Macroeconomics and Health, Ministry of Health and Family Welfare, Government of India, New Delhi, September 2005.

[154] National Crime Records Bureau. Accidental deaths and suicides in India. New Delhi Ministry of Home Affairs, Government of India; 2001b.

[155] National Crime Records Bureau. Accidental deaths and suicides in India of Home Affairs, Government of India; 2001c.

[156] National Crime Records Bureau. Crime in India. New Delhi: Ministry of Home Affairs, Government of India; 2001a.

[157] Neale, J.M., Liebert, R.M., 1986. Science and behavior: An Introduction to methods of research. Prentice –Hall international Inc. NJ.1986

[158] Niklas Krause., 2005. Physical workload, work intensification, and prevalence of pain in low wage workers: Results from a participatory research project with hotel room cleaners in Las Vegas. American Journal of Industrial Medicine 48 (5), 326–337.

[159] Nunnally, J, M., 1978. Psychometric theory, 2nd ed. New York: McGraw-Hill.

[160] Nwaka, O.M., Africa and the informal sector. 2008. Retrieved from http://www online Nigeria.com on February 25, 2012.

[161] O'Toole, M., 2002. The relationship between employees' perceptions of safety and organizational culture. Journal of Safety Research 33, 231–243.

[162] Occupational Analysis Series - Welders, 2009. Trades and apprenticeship division. Canada.

[163] Ory, D.T., Mokhtarian, P.L., 2009. Modeling the structural relationships among short distance travel amounts, perceptions, affections, and desires, Transportation Research Part A 43(1), 26-43.

[164] Papazoglou, I., Ale, B., 2007. A logical model for quantification of occupational risk. Reliability Engineering and System Safety 92, 785–803.

[165] Parihar, Y,S., Patnaik, J,P., Nema, B,K., Sahoo, G,B., Misra, I,B., Adhikary S., 1997. Coal workers' pneumoconiosis: A study eastern Madhya Pradesh and Orissa states of India. Indian Health 35, 467-73.

[166] Paul, P., Maiti, J., 2005. Development and test of a socio technical model for accident injury occurrences in underground coalmines. The Journal of the South African Institute of Mining and Metallurgy 105, 1–12.

[167] Paul, P., Maiti, J., 2007. The role of behavioral factors on safety management in under ground mines. Safety Science 45, 449–471.

[168] Paul, P., Maiti, J., 2008. The synergic role of sociotechnical and personal characteristics on work injuries in mines. Ergonomics 51, 737–767.

[169] Perrow, C., 1984. Normal accidents: living with high risk technologies, second ed. Princeton University Press.

[170] Petersen, D., 1989. Techniques of safety management: A Systems Approach, third ed. Aloray Goshen, New York.

[171] Pines, A., Halfon, S., and Prior, R., 1987. Occupational accidents in the construction industry of Israel. Journal of Occupational Accidents 9, 225–243.

[172] Pokorny, M, L, I., Blom, D,H., Van Leeuwen, P., 1987. Shifts, duration of work and accident risk of bus drivers. Ergonomics 30(1), 61-88.

[173] Powell, P.I., Hale, M., Martin, J., Simon, M., 1971. Accidents: A Shop OOR study of their causes. National Institute for Industrial Psychology, London.

[174] Prabhakara GN. Short textbook of preventive and social medicine, 2002 India : Jaypee brothers pp.33.

[175] Prussia, G., Brown, K., Willis, G., 2003. Mental models of safety: do managers and employees see eye to eye? Journal of Safety Research 34, 143–156.

[176] Putz-Anderson, V., 1988. Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limbs. Taylor and Francis, London.

[177] Quinlan.M., Mayhew.C., Bohle, P., 2000. The global expansion of precarious employment, work disorganization and occupational health. A review of recent research International Journal of Health Services 31(2), 36 – 39.

[178] Rahman, S., 2000. Towards developing an international market selection decision framework. In Proceedings of ANZMAC 2000 Visionary Marketing for the 21st Century: Facing the Challenge.

[179] Rao-Tummala, V., Leung, Y., 1996. A risk management model to assess safety and reliability risks. International Journal of Quality and Reliability Management 13, 53–62.

[180] Rathnakara, U,P., Krishna Murthy, V., Rajmohan, H,R., Nagarajan, L., Journal of Environmental Health 45, 289-92.

[181] Reason, J., 1990. Human error. Cambridge University Press.

[182] Robertson, L., 1998. Injury epidemiology: research and control strategies. Oxford University Press, New York.

[183] Rundmo, T., 1996. Associations between risk perception and safety. Safety Science 24, 197–209.

[184] Sabitu, K., Iliyasu, Z., and Dauda, M. 2015. Awareness of occupational hazards and utilization of safety measures among welders in Kaduna metropolis. Annals Of African Medical Journal, 8(1), 46-51.

[185] Saha, A., Kulkarni, P, A., Chaudurai, R., Saiyed, H., 2005. Occupational injuries: is job security a factor. Indian Journal of Medical Science 59(9), 375-381.

[186] Salminen, S., 2004. Have young workers more injuries than older ones? An international literature review. Journal of Safety Research 35, 513–521.

[187] Salminen, S., Saari, J., Saarela, K., Rasanen, T., 1992. Fatal and non-fatal occupational accidents: identical versus differential causation. Safety Science 15, 109–118.

[188] Sari, M., Duzgun, H., Karpuz, C., Selcuk, A., 2004. Accident analysis of two Turkish underground coal mines. Safety Science 42, 675–690.

[189] Sarma, B,P., 2001. Epidemiology and man-days loss in burn injuries amongst workers in an oil industry. Burns 27:475-80.

[190] Schoemaker, M.J., Barreto, S.M., Swerdlow, A.J., Higgins, C.D., Carpenter, R.G., 2000.Non-fatal work related injuries in a cohort of Brazilian steelworkers. Occupational and Environmental Medicine 57, 555–562.

[191] Schroeder D.J., Rosa R.R., Witt L.A., 1998. Some effects of 8- vs. 10-hour work schedules on the test performance/ alertness of air traffic control specialists. International Journal of Industrial Ergonomics 21:307–321.

[192] Seo, D., 2005. An explicative model of unsafe work behavior. Safety Science 43, 187–211.

[193] Shaikh, T.Q., Bhojani, F.A., 1991. Occupational injuries and perception of hazards among road side welding workers. Journal of Pakistan Medical Association 41(8), 187-8.

[194] Shannon, H., Manning, D., 1980. Differences between lost time and non lost time industrial accidents. Journal of Occupational Accidents 2, 265–272.

[195] Sharma, B,R., Harish, B., Sharma, V., Krishnan, V., 2001. Road traffic accidents: A demographic and topographic analysis. Medicine and Science.

[196] Sheu, J., Hwang, J., Wang, J., 2000. Diagnosis and monetary quantification of occupational injuries by indices related to human capital loss: analysis of a steel company as an illustration. Accident Analysis and Prevention 32, 435–443.

[197] Shukla, A., Kumar, S., Ory, F,G., 1991. Occupational health and the environment in an urban slum in India. Social Science and Medicine 33, 597-603.

[198] Salminen, S., 2010. Shift work and extended working hours as risk factors for occupational injury. The Ergonomics Open Journal. 3, 14-18.

[199] Singleton, W., 1984a. Application of human error analysis to occupational accident research. Journal of Occupational Accidents 6, 107–115.

[200] Siu, O., Phillips, D., Leung, T., 2004. Safety climate and safety performance among construction workers in Hong Kong- the role of psychological strains as mediators. Accident Analysis and Prevention 36, 359–366.

[201] Smith, G., Huang, Y., H.O, M., Chen, P., 2006. The relationship between safety climate and injury rates across industries: the need to adjust for injury hazards. Accident Analysis and Prevention 38, 556–562.

[202] Sobaszek, A., Edme, J., Boulenguez, C., Shirali, P., Mereau, M., Robin, H., Haguenoer, J., 1998. Respiratory symptoms and pulmonary function among stainless steel welders. Journal of Occupational and Environmental Medicine, 40(3), 223-229. doi:10.1097/00043764-199803000-00004.

[203] Soloman, K., Alesch, K., 1989. The index of harm: a measure for comparing occupational risk across industries. Journal of Occupational Accidents 11, 19–35.

[204] Stern, R,M., Berlin, A., Fletcher, A,C., Jarvisalo, J., 1986. Health hazards and biological effects of welding fumes and gases. International Congress Series 676, Excerpta Medica, New York.

[205] Stewart, W.F., Ricci, J.A., Chee, E., Morganstein, D., 2003. Lost productive work time costs from health conditions in the United States: results from the American productivity audit. Journal of Occupational and Environmental Medicine 45, 1234–1246.

[206] Storbakken, R., 2002. an incident investigation procedure for use in industry. Master's thesis, The Graduate School, University of Wisconsin-Stout, Menomonie, WL

[207] Suokas, J., 1988. The role of safety analysis in accident prevention. Accident Analysis and Prevention 20, 67–85.

[208] Sureshchander, G.S., Rajendran, c, Anantharaman, R.N., 2001. A Holistic Model for Total Quality Service. International Journal of service Industry Management 12,378-412.

[209] Tayyari, F., and Smith, J., 1997. Occupational ergonomics: principles and applications. Kluwer Academic Publishers, Boston.

[210] The Hindu, April 19, 2000. Workplace injury: Is there a solution for colossal loss?

[211] Tiwari, R,R., Saiyed, H,N., 2004. Occupational health research in India. Indian Health 42, 141-8.

[212] Tixier, J., Dusserre, G., Salvi, O., and Gaston, D., 2002. Review of 62 risk analysis methodologies of industrial plants. Journal of Loss Prevention in the Process Industries 15, 291–303.

[213] Torner, M., Zettererg, C., Anden, U., Hansson, T., Lindell, V., 1991. Workload and musculoskeletal problems: A comparison between welders and office clerks (with reference also to fishermen). Ergonomics 9, 1179-96.

[214] Trimpop, R., Kirkcaldy, B., Atanhosau, J., 2000. Individual difference in working hours, work perceptions and accident rate. Work and Stress 14, 181 -8.

[215] Trist, E., Bamforth, K., 1951. Some social and psychological consequences of the long-wall method of coal-getting. Human Relations 4, 3–38.

[216] Tuominen, R., Saari, J., 1982. A model for analysis of accidents and its application. Journal of Occupational Accidents 4, 263–273.

[217] Twin, S., Roberts, B., Andrew, S., 2008. Community health care nursing; principles for practice, (second ed.). Reed : Educational and professional publishing.

[218] Vasundhra, M,K., 1992. An enquiry into work environmental status and health of workers involved in production of incense sticks in city of Bangalore. Indian Journal Public Health 36, 38-44.

[219] Vegso S, Cantley L, Slade M, et al 2007. Extended work hours and risk of acute occupational injury: a case-crossover study of workers in manufacturing. American Journal of Industrial Medicine - 50(8): 597-603.

[220] Vinodkumar, M.N., Bhasi, M., 2009. Safety climate factors and its relationship with accidents and personal attributes in the chemical industry. Safety Science 47, 659–667.

[221] Warner, M., Schenker, N., Heinen, M. A., 2005. The effects of recall on reporting injury and poisoning episodes in the National Health Interview Survey. Injury Prevention, 11 , 282–287.

[222] Webster, 2002. Webster's Third New International Dictionary: Unabridged. Merriam Webster Inc.

[223] Wegge, J., Schmidt, K.K., Parkes, C., Van Dick, R., 2007. 'Taking a sickie': job satisfaction and job involvement as interactive predictors of absenteeism in a public organization, Journal of Occupational and Organizational Psychology, 80, 77–89.

[224] Wehmeier, S., McIntosh, C., Turnbull, J., Ashby, M., 2005. Oxford Advanced Learner's Dictionary of Current English, seventh ed. Oxford University Press.

[225] Wiktorin, C., Karlqvist, L., Winkel, J., and Stockholm MUSIC Study Group, 1993. Validity of self reported exposures to work postures and manual materials handling, Scandinavian Journal of Work Environment Health 19, 208–214.

[226] Willquist, P., Torner, M., 2003. Identifying and analysing hazards in manufacturing industry- a review of selected methods and development of a framework for method applicability. International Journal of Industrial Ergonomics 32, 165–180.

[227] Woods, V., 2005. Work related musculoskeletal health and social support. Occupational Medicine 55, 177-189.

[228] World Health Organisation, 2003b. Injury prevention and control. An epidemiological survey of injuries in area of Municipal Corporation of Delhi. New Delhi, SEA-injuries-5.

[229] Wright, D,B., 1997. Understanding statistics: an introduction for the social sciences. London: Sage. pp. 81-92.

[230] Zohar, D., 1980. Safety climate in industrial organizations: theoretical and applied implications. Journal of Applied Psychology 65, 96–101.

[231] Zurada, J., Karwowski, W., Marras, W., 1997. A neural network-based system for classification of industrial jobs with respect to risk of low back disorders due to workplace design. Applied Ergonomics 28, 49–58

………ᵹᴓ………

# LIST OF PUBLICATIONS

## Conferences

- Mahesa Rengaraj R, M N Vinodkumar, (2014). "Analysis of work factors influencing high frequency low severity work injuries among welders for safety interventions. International Conference on Energy, Environment, Materials and Safety", December 10 -12, 2014, CUSAT.
- Mahesa Rengaraj R, M N Vinodkumar, (2014). "A study on influence of individual factors, precarious employment in work injury exposures among welders employed in organized fabrication units". International conference on Emerging Trends in Engineering and Management". December 30-31 2014, Sree Narayana Gurukulam College of Engineering, Ernakulam

## Journals

- Mahesa Rengaraj R, M N Vinodkumar and V.Neethu, (2017). Modeling of the Influence of Individual and Employment Factors on Musculoskeletal Disorders in Industry. Human Factors and Ergonomics in Manufacturing and Service Industry. Wiley Blackwell. (Under review)

# APPENDIX

**Figure AF.1 - Analysis of welder task I**

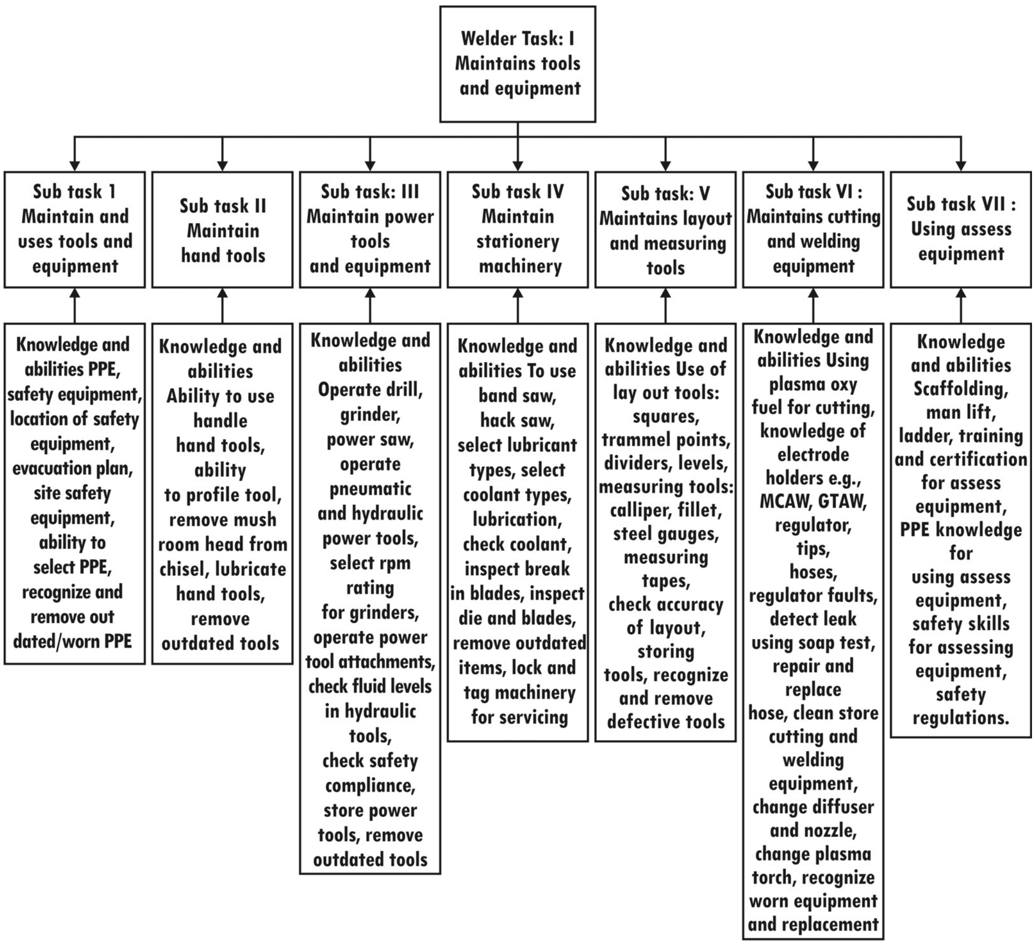


**Figure AF.2 - Analysis of welder task II**

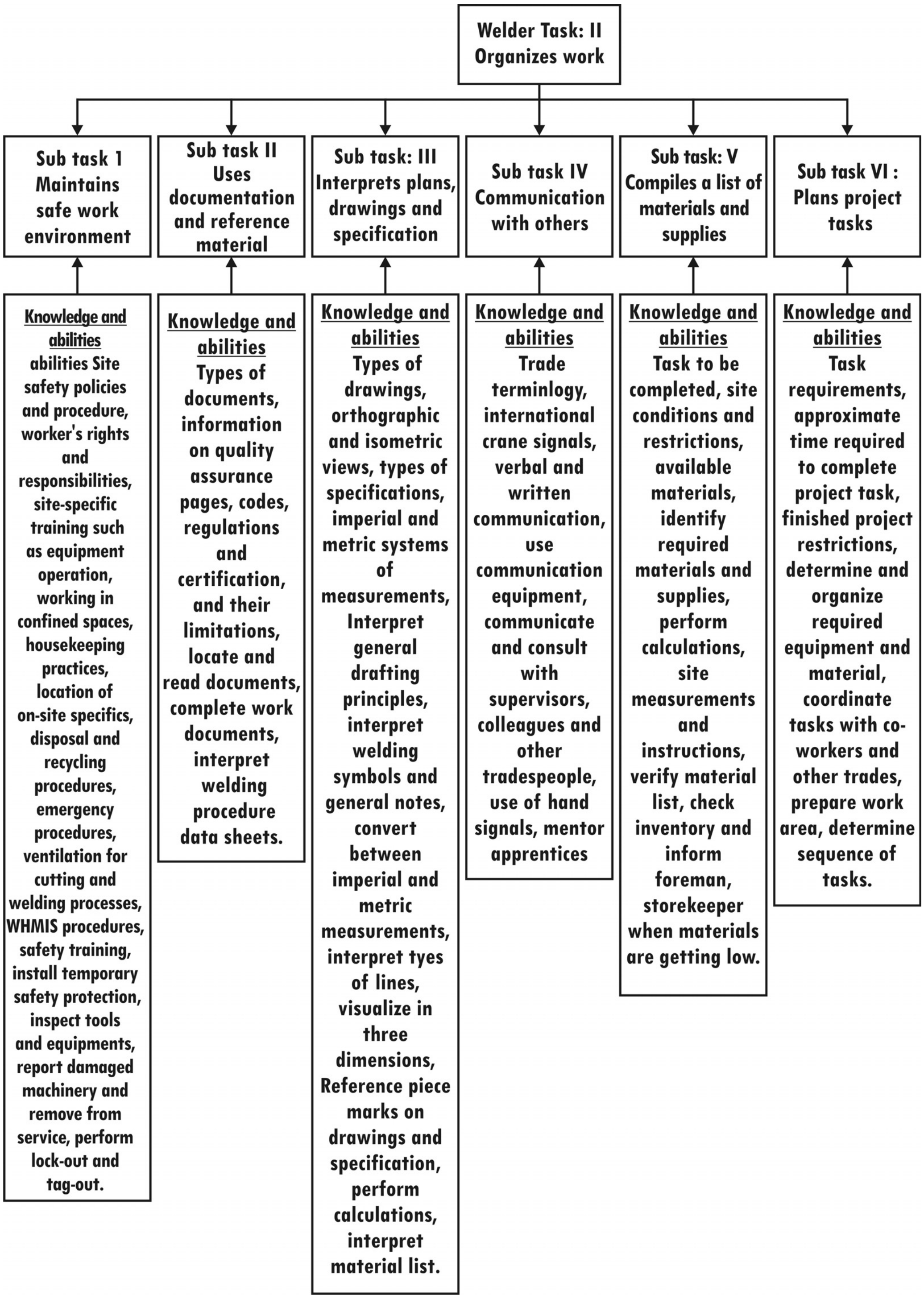
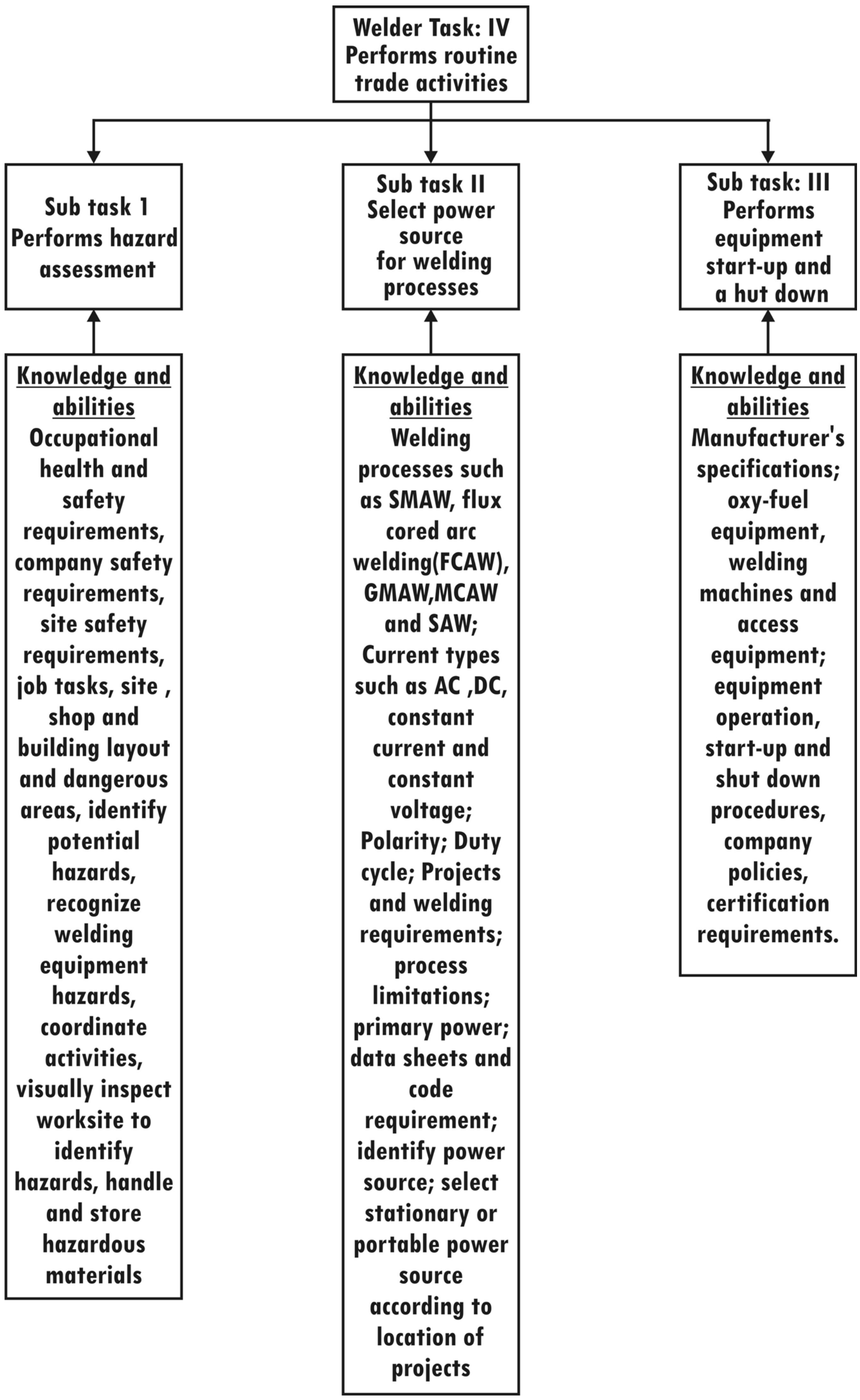


**Figure AF.3 - Analysis of welder task III**

**Figure AF.4 - Analysis of welder task IV**



# Figure AF.5 - Analysis of welder task V

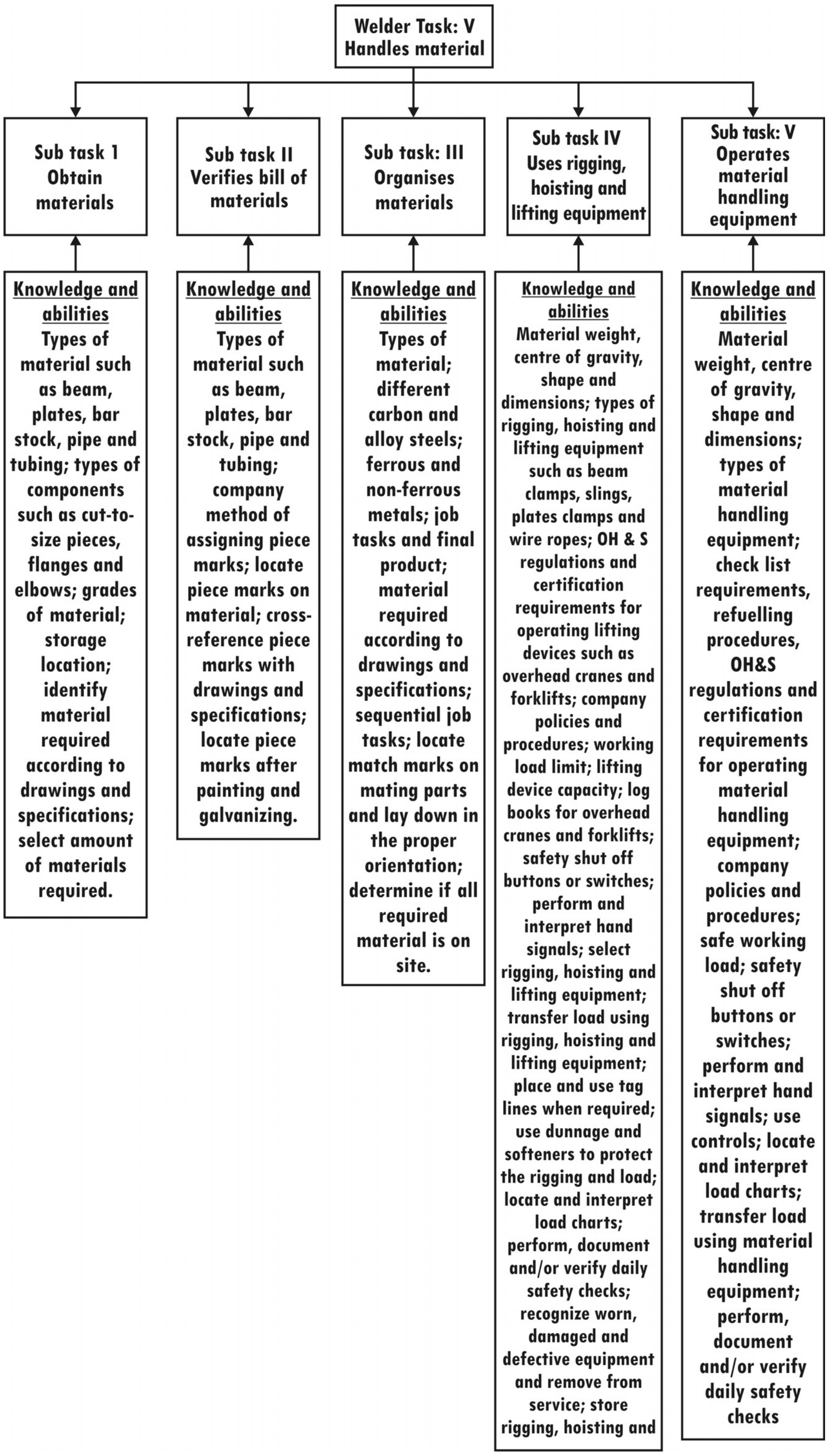


**Figure AF.6 - Analysis of welder task VI**

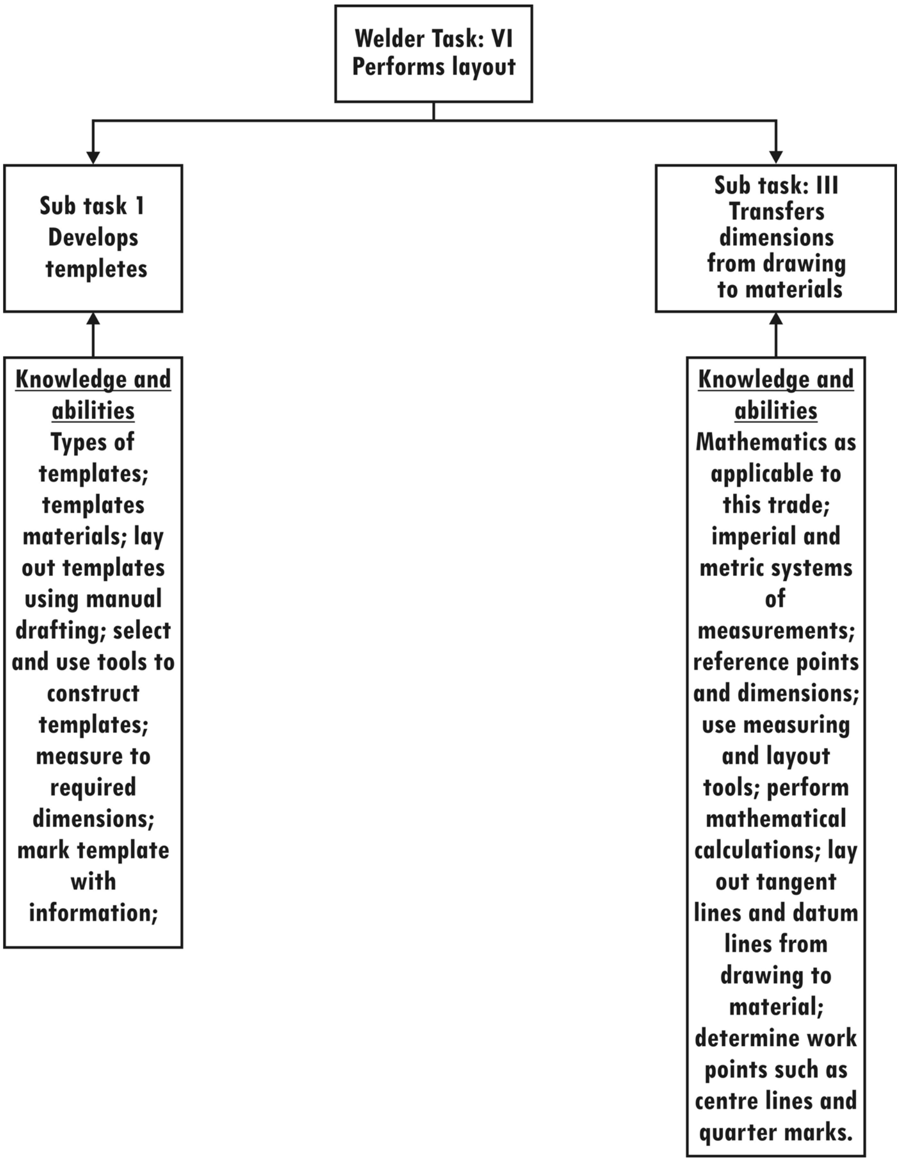


**Figure AF.7 Overall classification of energy expenditure factors**

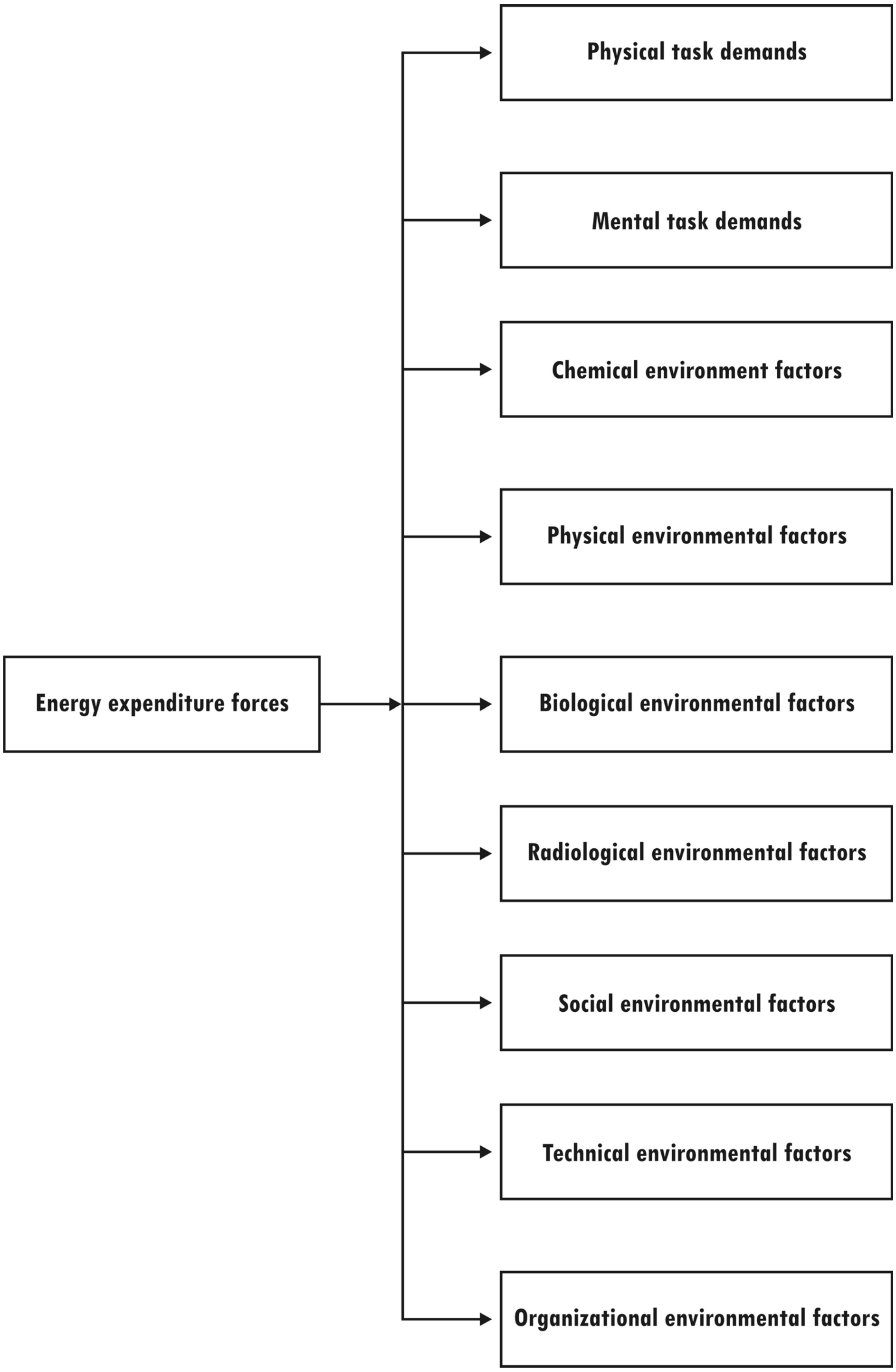


**Figure AF.8 Overall classification of energy replenishment factors**

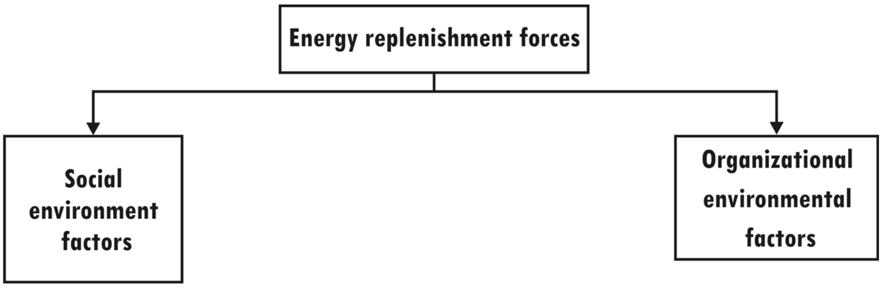


**Figure AF.9 Classification of physical task demands**

**(Energy expenditure loads)**

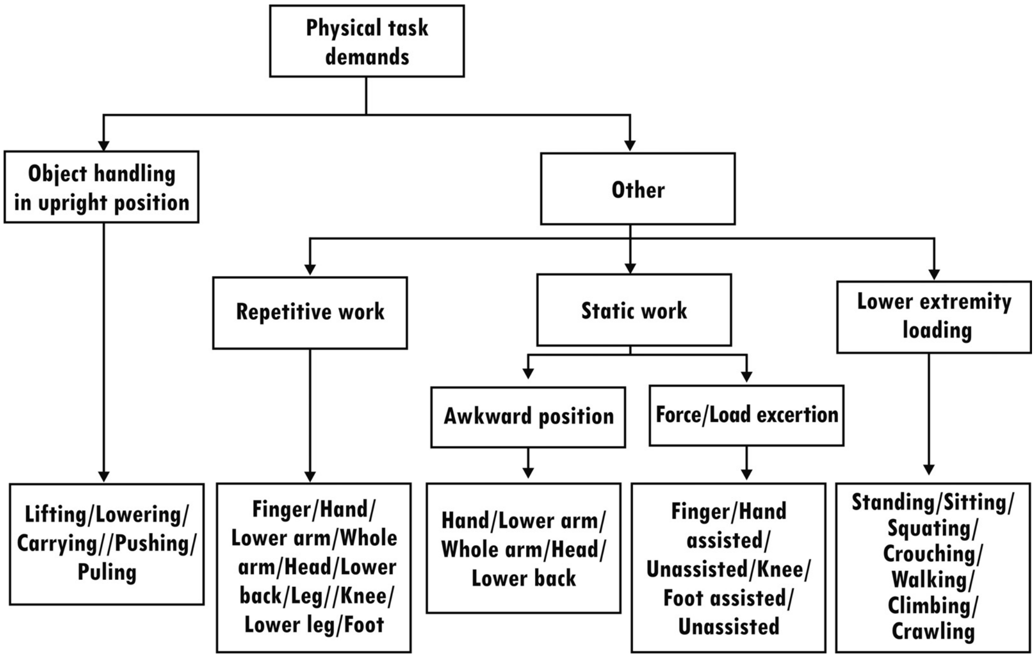


**Figure AF.10 Classification of mental task demands**

**(Energy expenditure loads)**

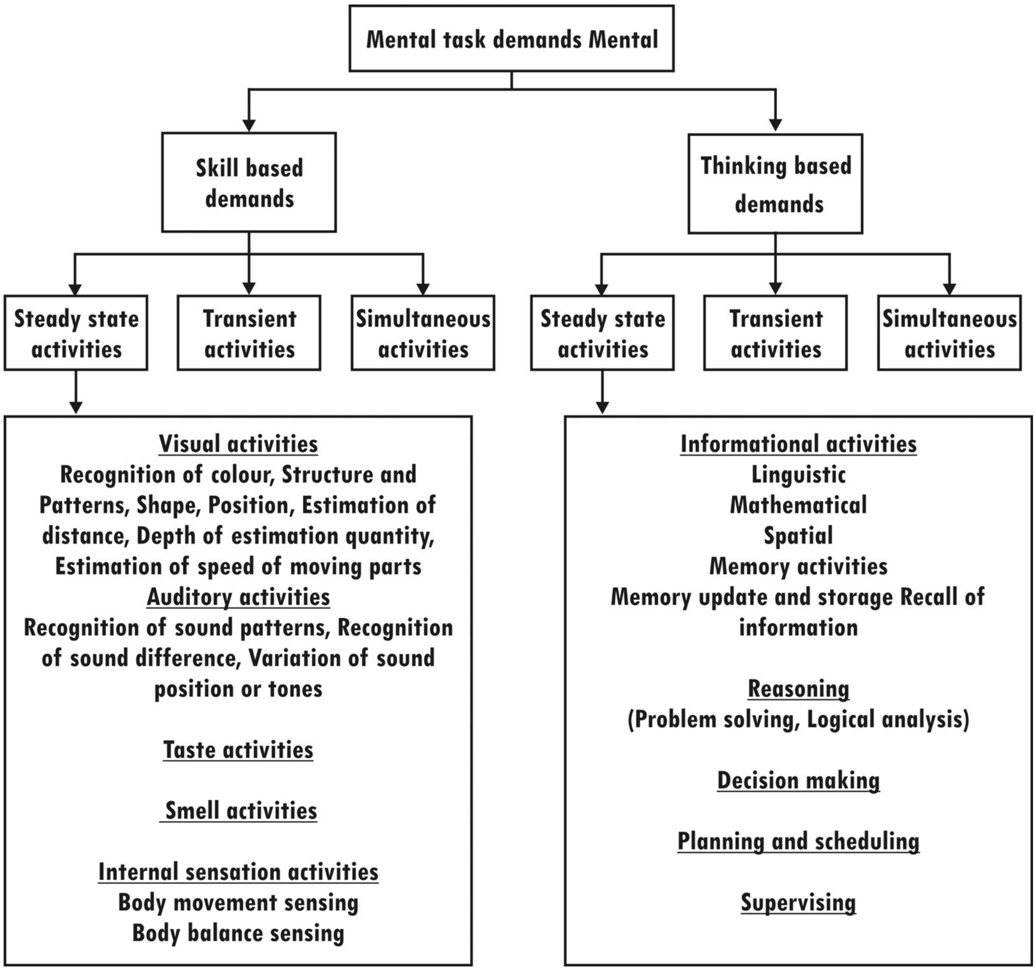


**Figure AF.11 Classification of physical environment conditions (Energy expenditure loads)**

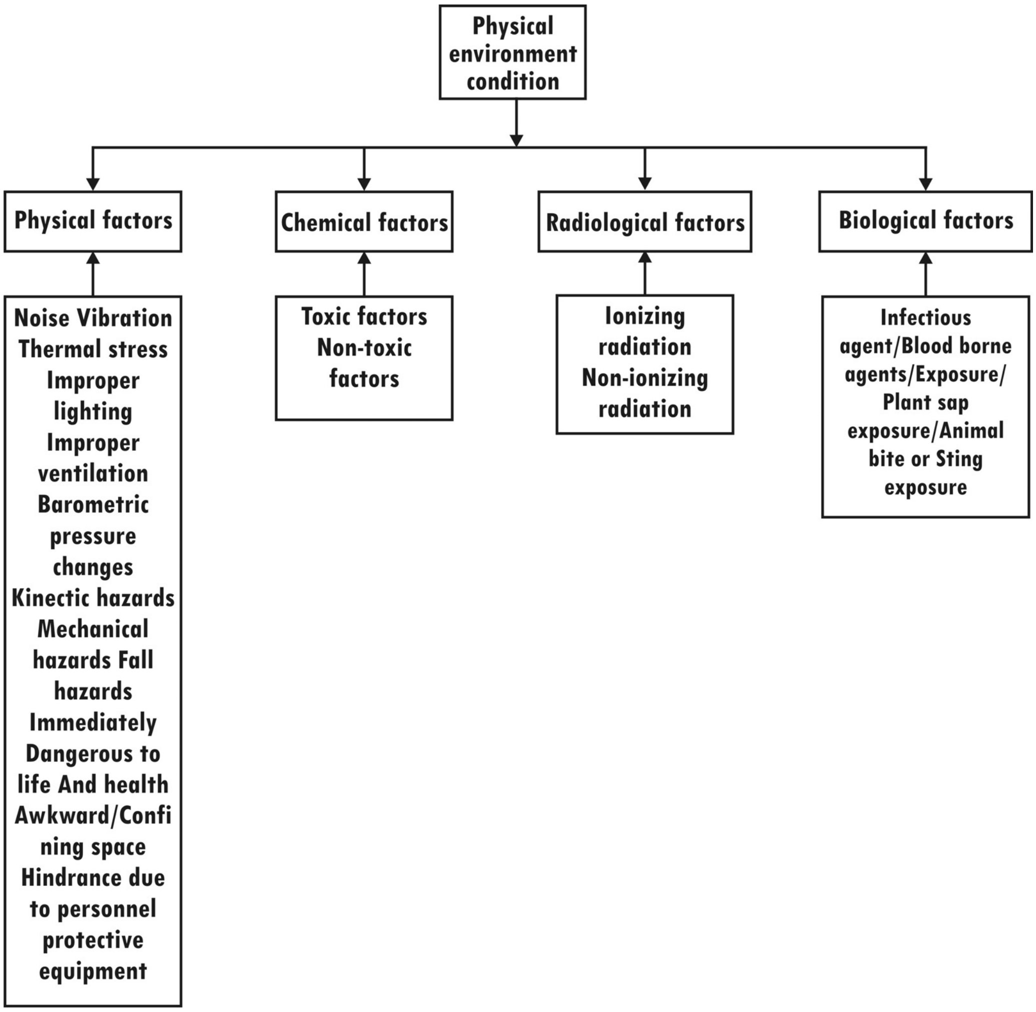


**Figure AF. 12 Classification of social environments**

**(Energy expenditure loads)**

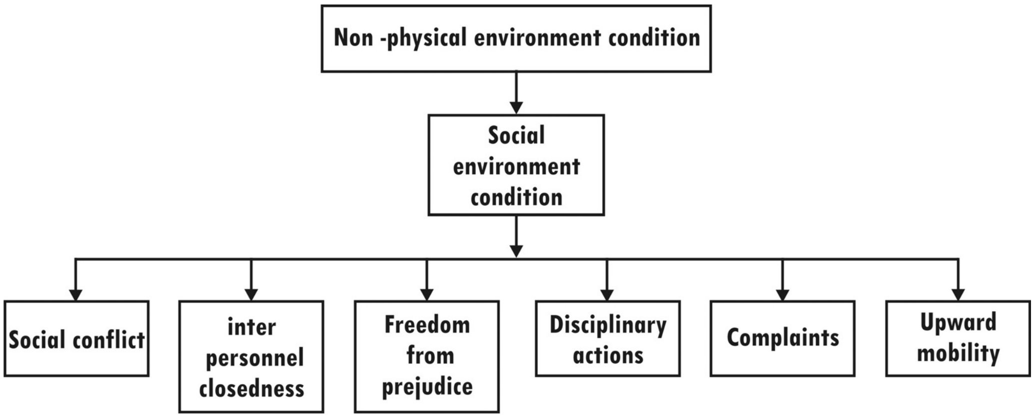


**Figure AF.13 Classification of organizational environmental conditions (Energy expenditure loads)**

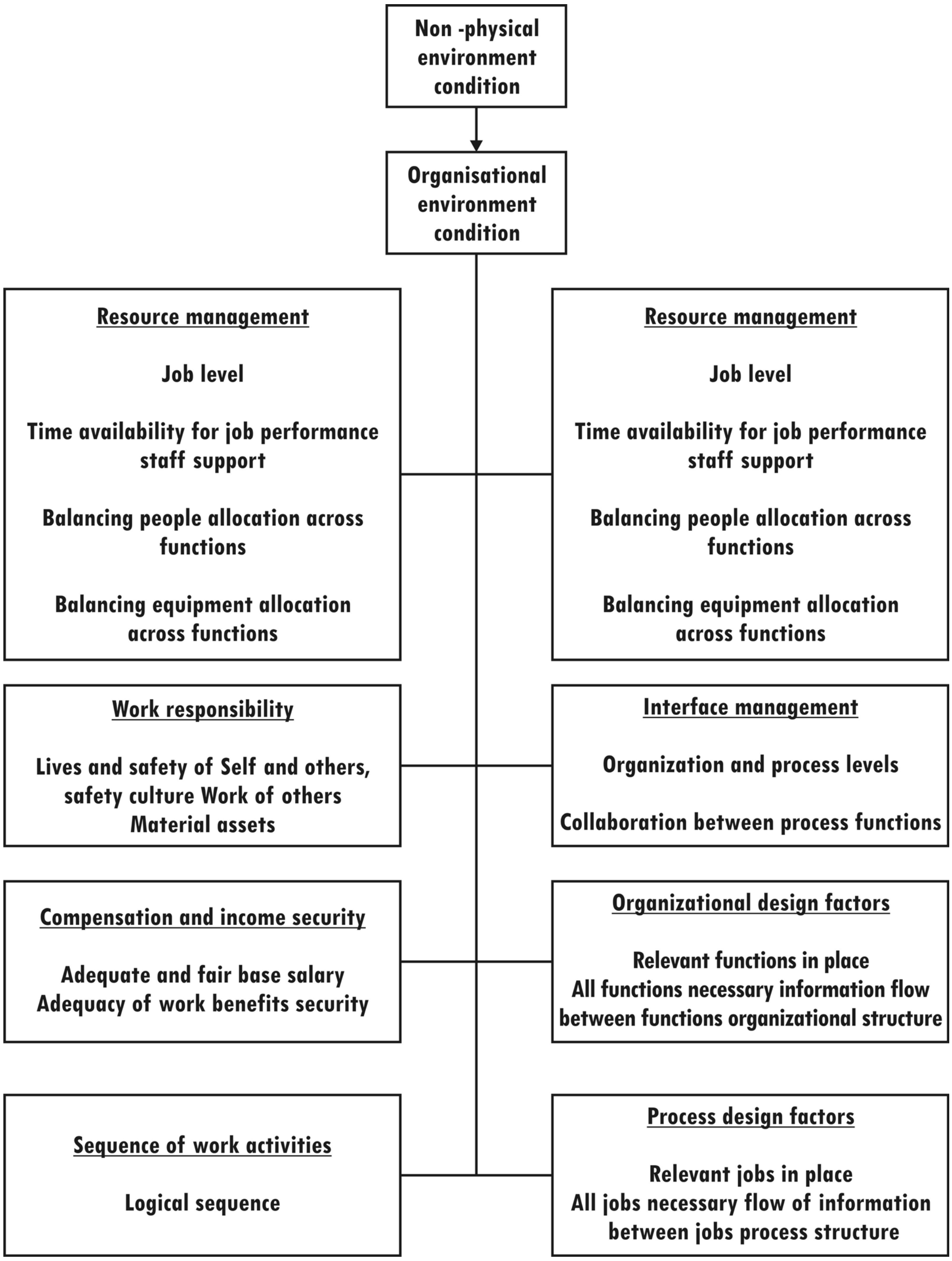


**Figure AF.14 Classification of technical environment conditions (Energy expenditure loads)**

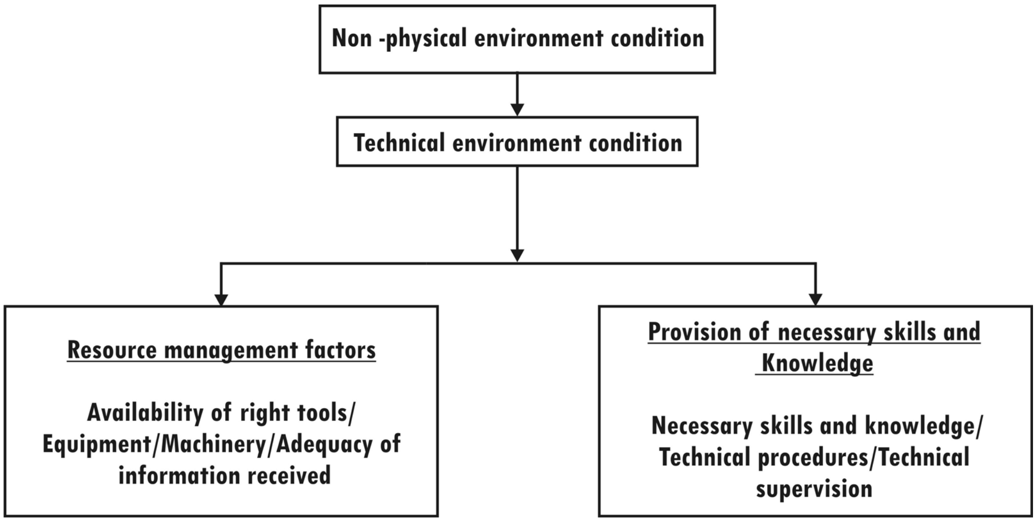


**Figure AF.15 Classification of organizational environment condition (Energy replenishment loads)**

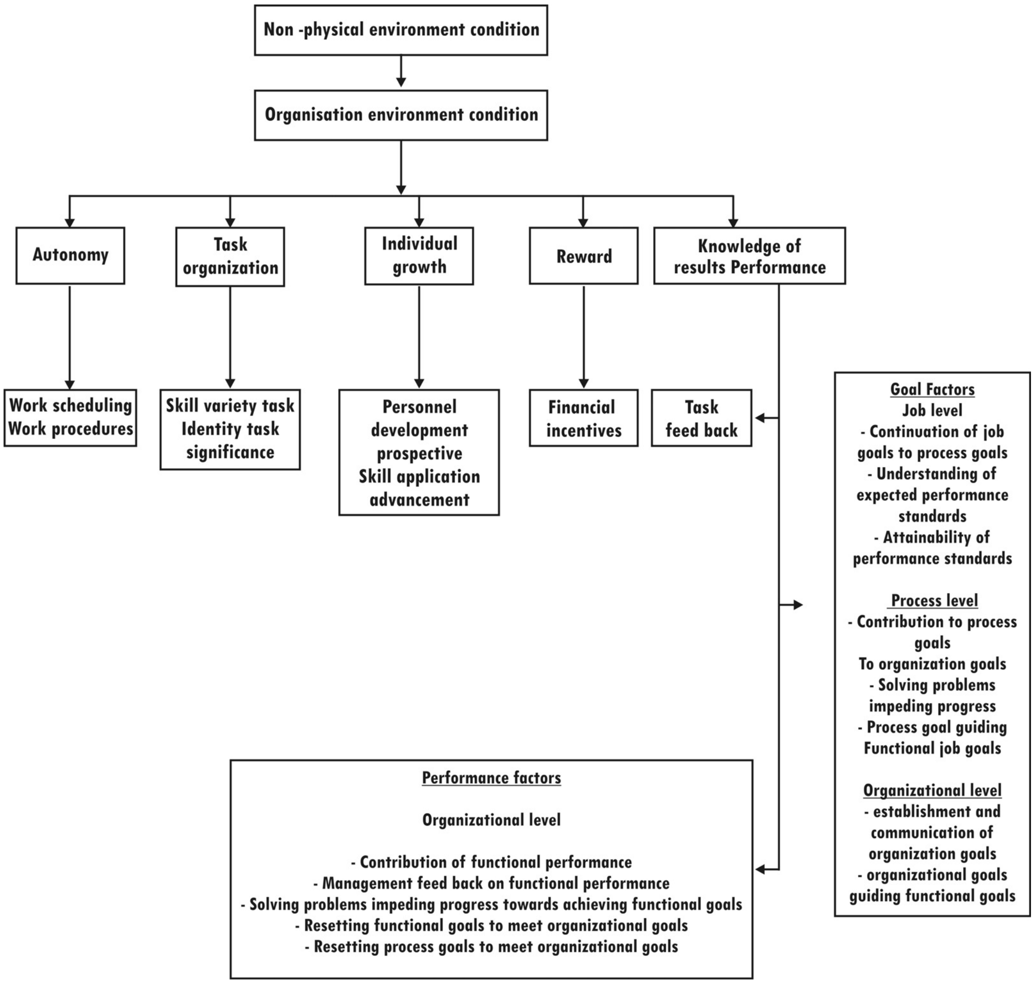


**Figure AF.16 Classification of social environment conditions (Energy replenishment loads)**

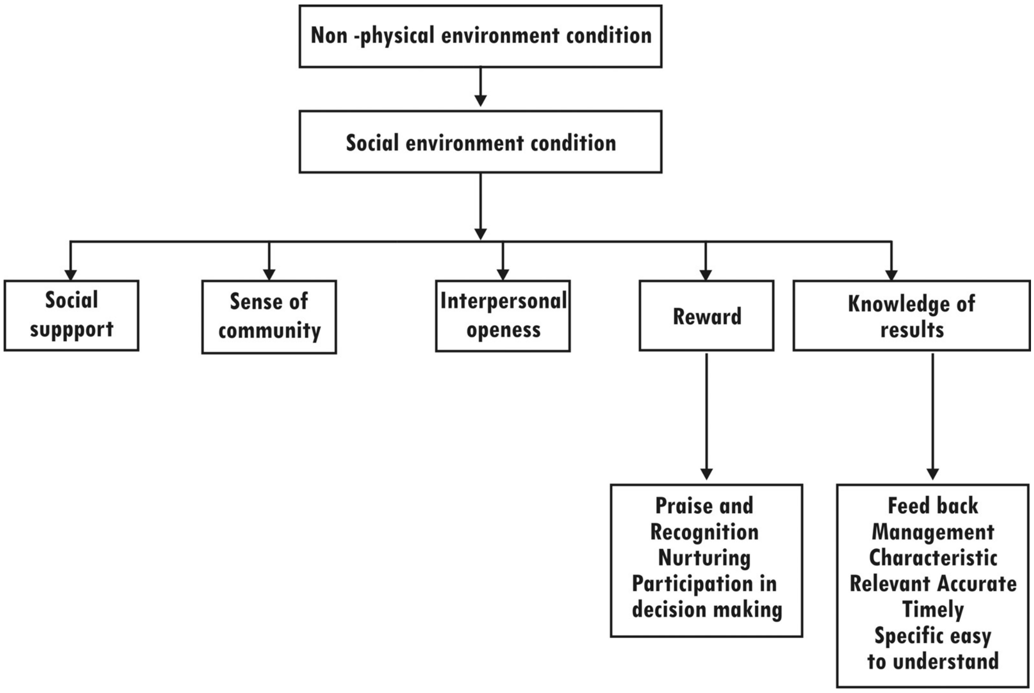


Figure AF.17 Tiruchirappalli Engineering Fabrication Cluster Map 2007 Supply Chain Management

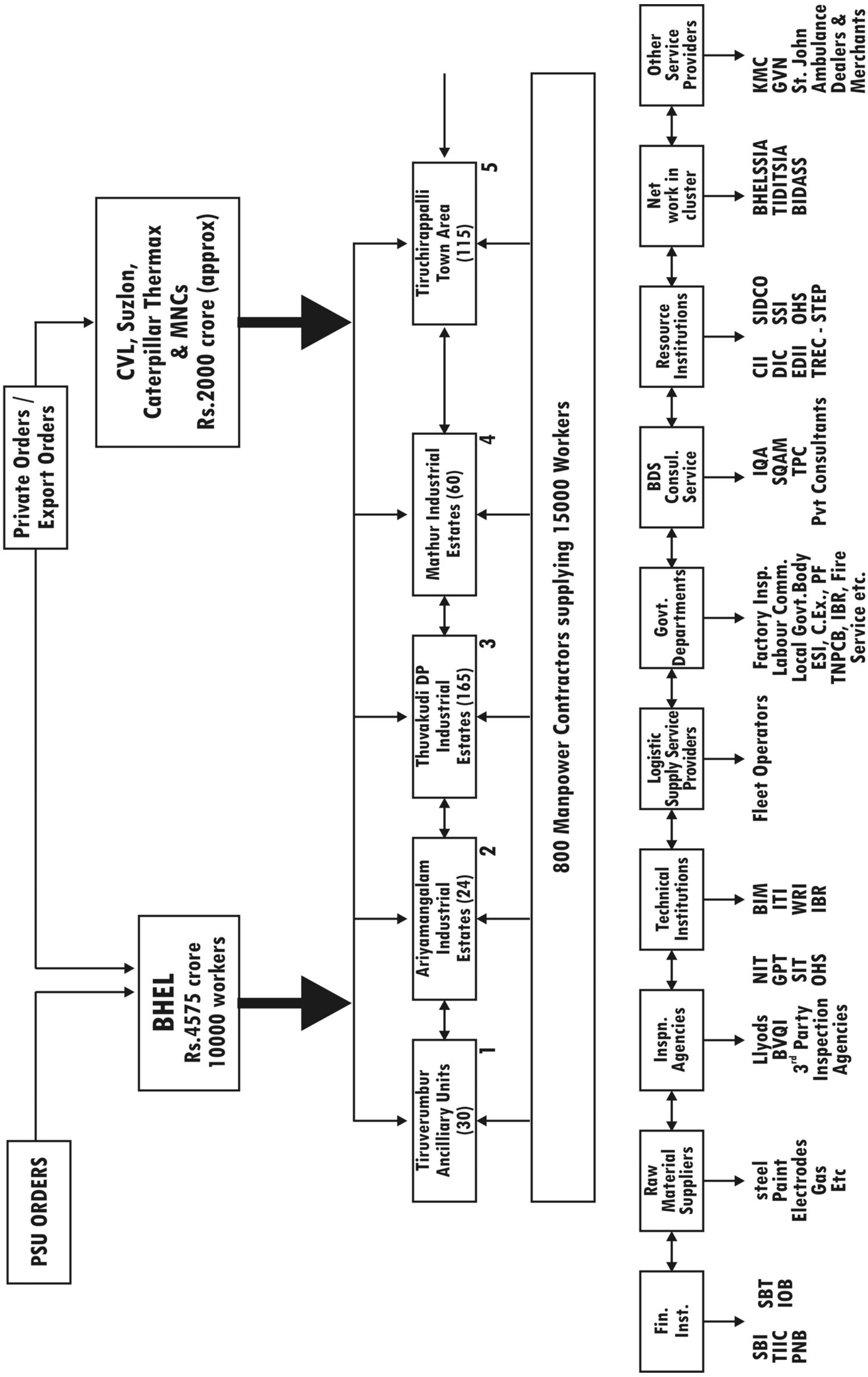


**Table.A1** Work Factor Domains - Final scale items, means and standard deviations

| SL No | Construct | Scale items | Summed items (means) | Construt reliability($\alpha$) | Source* |
|---|---|---|---|---|---|
| 1 | Health Perception (HP) | I have good health for welding work. | 4.20 (0.93) | 0.74 | Waldemar Karwowski 2000 |
| | | I have physical fitness to do welding work. | 3.92 (0.98) | | |
| | | I have good physical strength to do welding work. | 4.05 (0.84) | | |
| | | I have endurance to complete scheduled welding task. | 4.18 (0.94) | | |
| 2 | Safety Culture (SC) | Company provides training on health and safety. | 3.57 (1.07) | 0.72 | Vinodkumar and Bhasi 2008 |
| | | Company has openness on its safety policy. | 3.54 (1.04) | | |
| | | Company provides adequate training to recognize hazards. | 3.60 (1.09) | | |
| | | To complete welding task in time, I deviate from safe welding practices. | 3.52 (1.15) | | |
| | | There is significant danger in my work place. | 3.48 (1.12) | | |
| | | Job familiarity makes me deviate from the safe welding procedures. | 3.68 (1.00) | | |
| | | Practical difficulty is always present in following the safety practices. | 3.58 (1.18) | | |
| | | I work consciously to execute safe work. | 3.48 (1.14) | | |
| | | I personally ensure safety to execute safe work. | 3.48 (1.16) | | |
| | | I have adequate knowledge to execute safe work. | 3.58 (1.12) | | |
| | | Work injury rate is high in my welding trade practice. | 3.47 (1.26) | | |
| 3 | Physical Task Content (PTC) | I repeatedly weld by using finger, hands, lower arm, Knees, lower back for moderate and heavy weldment | 3.51 (1.13) | 0.68 | Genaidiy et al., 2000 |
| | | The posture which I use to perform weldment hurts my body. | 3.53 (1.08) | | |
| | | I exert reasonable force, on hand and leg during welding. | 3.51 (1.12) | | |
| | | My daily activities involve standing, squatting, crouching, walking climbing, crawling. | 3.53 (1.07) | | |

| SL No | Construct | Scale items | Summed items (means) | Construt reliability ($\alpha$) | Source* |
|---|---|---|---|---|---|
| 4 | Mental Task Content (MTC) | I use eyes to recognize flame colour, to infer weld quality. | 3.50 (1.19) | 0.61 | Genaidy et al., 2000 |
| | | I use eyes to determine the weld run for depositing metal. | 3.54 (1.16) | | |
| | | I relate sound for inferring quantity and quality of weld. | 3.60 (1.11) | | |
| | | My posture has relation in the weld quality. | 3.54 (1.17) | | |
| | | Drawing supplied, makes me to understand and do a effective welding, | 3.47 (1.16) | | |
| | | I usually decide on spot to perform a weldment. | 2.65 (1.19) | | |
| | | Welding a intricate job, consumes more time for planning and welding. | 3.86 (1.05) | | |
| | | Planning and scheduling followed by the firm makes more effective for welding work. | 2.69 (1.26) | | |
| 5 | Physical Environment (PE) | Noise in welding bay affects my work effectiveness. | 3.52 (1.18) | 0.68 | Genaidy et al., 2000 |
| | | Vibration during welding a job affects my weldment effectiveness. | 3.50 (1.20) | | |
| | | Heat generated during welding makes me more stressed. | 3.53 (1.19) | | |
| | | Work handling equipment (crane) helps me to make effective weldment. | 3.94 (0.88) | | |
| | | Consistent threat from splinters from the weldment affects my job effectiveness hence I adjust my posture | 3.72 (1.10) | | |
| | | Scaffoldings & Supports helps me to increase my welding effectiveness. | 3.52 (1.17) | | |
| 6 | Social Environment (SE) | Supervisor helps in complicated welding job. This makes easier for me to weld. | 3.60 (1.14) | 0.73 | Genaidy et al., 2000 |
| | | Conflict with fellow workers affects my job performance. | 3.46 (1.16) | | |
| | | Harmonious relation with workers increases my work effectiveness. | 3.58 (1.16) | | |
| | | I feel responsible for the welding I do as others safeties are involved. | 3.50 (1.04) | | |
| 7 | Technical Environment (TE) | Welding jobs are arranged in sequence, that aids me for effective weldment.. | 3.46 (1.20) | 0.68 | Genaidy et al., 2000 |
| | | Right tools are available at right place for me to weld effectively. | 3.46 (1.22) | | |
| | | Logically arranged work layout helps me to perform better. | 2.84 (1.32) | | |
| | | I learn from, technically difficult situations. | 3.57 (1.19) | | |
| | | I face high demand on doing technical auxiliary work as welder. | 3.17 (1.32) | | |
| 8 | Perceived Benefit (PB) | I have income security in the as welder. | 3.52 (1.14) | 0.67 | Genaidy et al., 2000 |
| | | Wage I get for my welding job relates to my productivity. | 3.60 (1.16) | | |

# QUESTIONNAIRE

1] Name:

**Optional**

2] Company you work has SSI registration

1. Registered  2. Not registered

3] Have you been injured during weldment work?

1. Yes*  2 No

**IF YES***

* State the number of times you used first aid to treat your injuries during last one month during continued welding work………………

4] Age:

5] How long are you working as a welder specify in ___________years.

6] How long do you work in a day?

1. 8 hours  2. More than 8 hours

7] Do you work in shifts?

1 Yes  2. No

8] Select the type of employment that suits you:

1. Regular  2. Contract

9] Mode of Apprenticeship training for welder trade knowledge

1. ITI welder certification
2. On the job training

10] Specify the amount of average number of welding rods you used frequently during weldment work during last one month.

Frequently used rod diameter:_________

Average number of rods of Rods:______

**HEALTH PERCEPTION**

1]. I have good health for welding work

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

2]. I have physical fitness to do welding work.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

3]. I have good physical strength to do welding work.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

4]. I work long hours to complete scheduled welding task.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

**SAFETY CULTURE**

5]. Company provides training on health and safety.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

6]. Company has openness on safety policy

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

7]. Company provides adequate training to recognize hazards.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

8] To complete welding task in time, I deviate from safe welding practices.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

9].There is significant danger in my work place.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

10]. Job familiarity makes me deviate from the safe welding procedures.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

11]. Practical difficulty is always present in following the safety practices.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

12]. I work consciously to execute safe work

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

*0 – Not Applicable 1- Strongly disagree 2- disagree 3-Undecided 4- Agree 5-Strongly agree*

13]. I personally ensure safety to execute safe work.

| 0 | ,1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

14]. I have adequate knowledge in executing safe work

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

15]. Work injury rate is high in my welding trade Practice.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

**PHYSICAL TASK CONTENT**

16]. I repeatedly weld by using finger, hands, lower arm, Knees, lower back for moderate and heavy welding.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

17]. The posture which I use to weld, hurts my body.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

18]. I exert reasonable force, on hand and leg during welding.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

19]. My daily activities involve standing, squatting, crouching, walking climbing, crawling.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

20]. I use eyes to recognize flame colour, to infer weld quality.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

**MENTAL TASK CONTENT**

21]. I use eyes to determine the weld run for depositing metal.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

22]. I relate sound for inferring quantity and quality of weld.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

23]. My posture has relation in the weld quality.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

24]. Drawing supplied, makes me to understand and do a effective welding,

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

25]. I usually decide on spot to perform welding.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

26]. Welding a intricate job, consumes more time for planning and welding.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

27]. Planning and scheduling followed by the firm makes more effective for welding work.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

**PHYSICAL ENVIRONMENT**

28]. Noise in welding bay affects my work effectiveness.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

29]. Vibration during welding a job affects my weldment effectiveness.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

30]. Heat generated during welding makes me more stressed.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

31 Work handling equipment (crane) helps me to make effective weldment

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

32]. Consistent threat from splinters from the weldment affects my job effectiveness hence I adjust my posture.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

33]. Scaffoldings & Supports helps me to increase my welding effectiveness.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

**SOCIAL ENVIRONMENT**

34]. Supervisor helps in complicated welding job. This makes easier for me to weld.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

*0 – Not Applicable 1- Strongly disagree 2- disagree 3-Undecided 4- Agree 5-Strongly agree*

35]. Conflict with fellow workers affects my job performance.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

36]. Harmonious relation with workers increases my work effectiveness.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

37]. Does your coworker help you to solve the help to solve problem at work

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

**TECHNICAL ENVIRONMENT**

38]. Welding jobs are arranged in sequence, that aids me for effective weldment..

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

39]. Right tools are available at right place for me to weld effectively.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

40]. Logically arranged work layout helps me to perform better.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

41]. I learn from, technically difficult situations.

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

42]. I face high demand on doing technical auxiliary work as welder

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

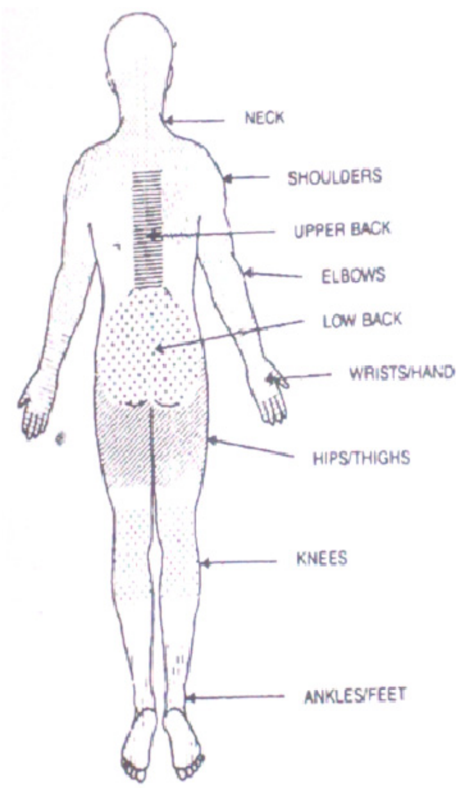
**PERCEIVED BENEFIT**

43]. I have income security in the as welder

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|

44]. Wage I get for my welding job relates to my productivity

| 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|




*Kindly Answer for the questions after referring the sketch*

*0 – Not Applicable 1- Strongly disagree 2- disagree 3-Undecided 4- Agree 5-Strongly agree*

| Nordic Questionnaire For Musculoskeletal Disorder | | | | | |
|---|---|---|---|---|---|
| **Have you had trouble/pain during last 7 days** | | **Have you at any times during last 12 months had trouble – (ache, pain, discomfort, dumbness ) put a tick mark** | | **During last 12 months have you been prevented for carrying normal activities ( eg: work ,house work, hobbies)** | |
| **1.Neck** | | **2.Neck** | | **3.Neck** | |
| 1.No | 2.Yes | 1.No | 2.Yes | 1.No | 2.Yes |
| **4.Shoulder** | | **5.Shoulder** | | **6.Shoulder** | |
| 1.No | 2.Yes | 1.No | 2.Yes | 1.No | 2.Yes |
| **7. Elbow** | | **8.Elbow** | | **9.Elbow** | |
| 1.No | 2.Yes | 1.No | 2.Yes | 1.No | 2.Yes |
| **10.Wrist/Hands** | | **11.Wrist/Hands** | | **12.Wrist Hands** | |
| 1.No | 2.Yes | 1.No | 2.Yes | 1.No | 2.Yes |
| **13.Upper Back** | | **14.Upper Back** | | **15.Upper Back** | |
| 1.No | 2.Yes | 1.No | 2.Yes | 1.No | 2.Yes |
| **16.Lower Back** | | **17.Lower Back** | | **18.Lower Back** | |
| 1.No | 2.Yes | 1.No | 2.Yes | 1.No | 2.Yes |
| **19.Hip/Thigh/Buttock** | | **20.Hip/Thigh/Buttock** | | **21.Hip/Thigh/Buttock** | |
| 1.No | 2.Yes | 1.No | 2.Yes | 1.No | 2.Yes |
| **22.Knees** | | **23.Knees** | | **24.Knees** | |
| 1.No | 2.Yes | 1.No | 2.Yes | 1.No | 2.Yes |
| **25.Ankles/Feet** | | **26.Ankles/Feet** | | **27.Ankles/Feet** | |
| 1.No | 2.Yes | 1.No | 2.Yes | 1.No | 2.Yes |

# CURRICULUM VITAE

The author of this thesis, Mahesa Rengaraj R was born in 1968 in Tiruchirappali district of Tamilnadu, India. He obtained his Bachelor of Engineering degree in Mechanical Engineering in the year 1994 from Bangalore University, Bangalore and Master of Engineering degree in Manufacturing Engineering in the year 2007 from Anna University, Chennai, Tamilnadu, India. Besides he holds Master of Business Administration degree with specialization in Marketing Management and Post Graduate Diploma in Computer Application from IGNOU New Delhi. He has about 22 years of experience in teaching. He started his career as Lecturer in Mechanical Engineering in Mookambigai College of Engineering, Keeranur, Pudukottai, Tamilnadu. Since 2008, he is employed as Associate Professor in Department of Mechanical Engineering in SCMS School of Engineering and Technology (SSET), Angamali, Kerala, India. The author joined the Division of Safety and Fire Engineering, School of Engineering, Cochin University of Science and Technology, in September 2008, as a doctoral student. His areas of interest include Safety engineering, Human Factors, Ergonomics and Management science.