Environmental Pollution and Health Costs Faced by Miners Working in Underground Coal Mines: Evidence from District Duki, Balochistan

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CERTIFICATE

This is to certify that this thesis entitled: **"Environmental Pollution and Health Costs Faced by Miners Working in Underground Coal Mines: Evidence from District Duki, Balochistan".** submitted by Muhammad Ayaz is accepted in its present form by the Department of Environmental Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in **Master of Philosophy in Environmental Economics**.

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Dedication

I dedicated this thesis to my Parents and my dear uncle, for their affection and passion towards my studies

Acknowledgement

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Abstract

This study examines environmental pollution and health costs faced by miners working in underground coal mines in Balochistan. The required information is obtained through primary source of data and questionnaire consisting of 300 samples size. It was analyzed through Double-hurdle model technique using Stata software. Results indicate that socio-economic and demographic variables such as age, education level, age when work started, income, frequency of illness, living condition, sources of safe drinking water and nationality of the respondents have significant impacts on the decision of getting treatment and costs of illness of coal mine workers. Environment related variables like poisonous gases (CH_4 and CO) are positively affecting direct cost of coal mine worker. Structure of coal mines i.e. width of coal seam is negative and statically significant impacts on direct costs of illness of coal mine workers. From results it is concluded that coal mine workers suffered more from different illnesses and their cost of illnesses are much higher as compared to non-coal workers. Among the various possible policy interventions the most important is the strict implementation of The Mine Act, 1923 and also the standards provided by ILO for mining sector. Moreover, protective measures, living environment and physical structure of mines could also be considered as critical policy recommendations.

***Keywords**:* Environmental Pollution, Health Costs, Coal Mines, Double-hurdle Model, Costs of Illness, Poisonous Gases, Structure of Coal Mines

Contents

List of figures

List of Tables

List of Abbreviations

WCS	World Coal Association
WEC	World Energy Council
IEA	International Energy Agency
EWG	Energy Watch Group
GSP	Geological Survey of Pakistan
CPEC	China Pakistan Economic Corridor
WHO	World Health Organization
HEAL	Health and Environment Alliance
NGOs	Non-Governmental Organization
ILO	International Labour Organization
CWP	Coal Workers Pneumoconiosis
CMDLD	Coal Mine Dust Lung Disease
NIOSH	National Institute of Occupational Health and Safety
EPA	Environmental Protection Agency

Chapter 1

Introduction

1.1 Background of the study

According to World Coal Association (WCA,1985) Coal is a fossil fuel and is the altered remains of prehistoric vegetation that originally accumulated in swamps and peat bogs. The energy we get from coal today comes from the energy that plants absorbed from the sun millions of years ago. The earth has many natural resources and coal is also one of the major resources of the earth. Every nation depends on these natural resources. To fulfill the energy requirement of the nations, these natural resources are extracted at the high cost of human health and environment. Coal is extracted by two ways, one is underground coal mining and the second is surface coal mining. The choice of coal mining method depends on the geology of the coal deposits (Goswami, 2015). Coal mining has been dangerous occupation since mining of coal began during colonial times (Reardon, 1993). Coal mining is one of the oldest economic activities in the history of civilization.

According to the German Federal Institute for Geosciences and Natural Resources, the world's reserves of coal are 968 billion tones. The study further estimated that 8 billion tones were mined and burned in 2013, (burned 253 tones in every second). It was also estimated that global deposits of lignite and hard coal may amount to 22,000 billion tones but currently uneconomical to exploit. The largest share of hard coal reserves which is economically viable are found in Asia, Australia, North America and Commonwealth of Independent States. According to World Energy Council (WEC, 2010), it was estimated that 80% of world's total coal reserves are located only in 10 countries. The United States of America has the largest reserves of hard coal 237 billion tones (28%) and Russia comes next with 157 billion tones

(18%), while China hold the third largest coal reserves of 114 billion tons (13%) but China was world's largest producer (47.%) and consumes (50%) of world coal reserves. According to International Energy Agency (IEA), since 2000 China remained the world's leading coal producer and Coal production increased by 139.3%. About 37 countries of the world are having coal reserves but eleven countries including USA, India, China, Australia and some other countries accounts 82% of worldwide coal production (Coal Atlas, 2015). The Energy Watch Group (EWG) , an international network of specialists, thinks that official estimates of coal reserves are too high and the group expects that we will reach peak global coal production as soon as 2020. Coal resources are accessible to 70 countries worldwide. Coal reserves are estimated to last in 112 years according to the current level of coal production (Coal Atlas, 2015)

Coal has multiple uses worldwide. Coal is used an important input to produce energy and considered the backbone of power generation in many countries. It was estimated that 66 % of primary coal being used for electricity generation and commercial heat (IEA, 2015). According to World Coal Association (WCA), 41 percent of global electricity is currently produced by using coal in coal fired power plants. Hard coal is also used as a source of energy in steel production, cement production. There is no exaggeration that coal is regarded by many people as a black diamond.

God has gifted Pakistan with immense natural resources. Pakistan has the 7^{th} largest coal reserves in the world. The total coal reserves in Pakistan is 185 billion tones (GSP, 2003), within which 'measured reserves' was 3.45 billion tones, 'indicated reserves' nearly 12 billion tones, 'inferred reserves' 57 billion and 'hypothetical resources' 113 billion (World Energy Council,2010). According to (GSP, 2003) coal deposits are located in all the provinces of Pakistan and Azad Kashmir. The largest coal reserves are in Sindh, which is about 175 billion tones, followed Punjab (235 million tons), Baluchistan (217 million tons) and Khyber Pakhtunkhwa (KPK) has 90 million tons. There are four types of coal reserves found in Pakistan which includes Anthracite (1%), lignite (17%), Bituminous (52%) and Sub-bituminous (30%). A large coal reserve with potential of about 175 billion tones has been discovered at Thar in the eastern part of Sindh province. Their coal field extends over 9,000 sq km, out of which 356 sq km has been studied by Geological Survey of Pakistan (GSP). According to the Pakistan Economic Survey (PES, 2017), during fiscal year of 2016-2017, the total extraction of coal was 4,605,807 Mt. The GPS also estimated that just 2 % usage of Thar coal every year can produce 20,000 MW of electricity for next forty years. In Pakistan only 0.8% electricity is generated from coal. Besides electricity Coal in Pakistan is used in different sectors like brick line, cement manufacturing, and source of energy for housing sectors. Mining sectors contribute 3% to GDP and employs 0.3 percent of the work force (PEC, 2012-2013). Recently, Pakistan has made an agreement with China for a project named as (China-Pakistan Economic Corridor (CPEC, 2016) under this project China will assist Pakistan to construct six coal power plants for power generation to overcome the energy requirements of the country. According to the official website of CPEC, these coal power plants will be installed at different location (Port Qasim, Sahiwal, Gawadar, Hub, Balochistan and Thar) of Pakistan (Gop, 2017). Three of them already are completed and the capacity of the all coal-fired plants is estimated to produce 3960 MW of electricity per annum.

1.2 Problem Statement and Significance of the Study

It is estimated that seven million people are employed worldwide in the coal industry (Coal Atlas, 2015). Coal mining provides employment to a large number of labours and they are also considered as the most important factors of coal extraction but unfortunately health risk of these workers is not properly taken care. Coal mining is considered as one of the dangerous occupation globally and possesses many health problems to coal miners due to production and dispersion of coal dust[1]. According to World Health Organization (WHO, 2012), 3.7 million people died worldwide as a result of outdoor air pollution and burning coal. Health and Environment Alliance (HEAL), a coalition of 65 Europe Non- Governmental Organization (NGOs) blame coal power for 18,200 deaths in the European Union annually. HEAL also estimated that health cost reach almost 43 billion euro a year. However, because of low literacy rate and ineffective labour unions, majority of these workers are unaware of their basic rights. Pakistan has not ratified the International Labour Organization's (ILO) Safety and Health in Mines Convention 1995 (No.175) and neither does it follow the 2006 code on Safety and Health of underground coal mines. Putting labour in the forefront of development is a positive sign of social change but their health safety is also important not only for ethical reasons but also to exploit their maximum potential. Descending into dark, airless tunnels, coal mines workers extract coal with simple tools without adopting any protective measures (Gas mask, gloves, special dress etc.), in addition to this no special training has been imparted to workers before sending them into underground coal mines. Hence, Inhalation in the presence of poisonous gases (CH_4, CO_2, CO, and O_2 below threshold limits), explosions and coal mines dust are responsible to cause several types of diseases. Among these includes illness of respiratory system, kidney failure, headache,

[1] Coal dust is a fine powdered form of coal, which is produced by the crushing, grinding, or pulverizing of coal. Because of the brittle nature of coal, coal dust can be created during mining, transportation, or by mechanically handling coal.

drowsiness, ear problem, and irritation in eyes, throat and nose, nervous problems, musculoskeletal troubles etc. Without having the monetary value of economic damages, it is impossible to convince the policy makers to implement labour rules in its full spirits. In the presence of coal power plants under CPEC, the share of coal energy is expected to increase, under such scenario the importance to estimates the monetary values of health damages of coal mine workers has further amplified. Therefore, present study will fill this gap by estimating the monetary values of health damages faced by coal mine workers. This will help to convince the policy makers to revisit the legislation process for coal mine workers.

1.3 Contribution of the present study

There are many studies done to explore the different aspects of coal mining in different parts of world. According to the World Health Organization (WHO, 2012), air pollution is one of the major health risk. Laney et al., (2014) and Ross and Murray, (2014) observed positive relationship between coal mine dust and lung diseases of workers. Laney et al., (2012) observed black lung [2] known as coal workers pneumoconiosis (CWP) among coal workers. Steyn, and Edward, (2007) investigated the impact of awareness and environmental standards on workers' health and found negative relationship between awareness and health problems. Higher concentration of methane (CH_4) gas in coal mines can lead to lower the percentage of oxygen [3] (O_2) from the required level of (18%), cause suffocation and deaths among coal mines workers (Walter et al., 2001). Yohi et al., (2007) observed a positive relationship between coal production and number of deaths. In Pakistan Ishatiaq et al., (2014) concluded that health of majority of coal

[2] Black lung is called the chronic condition caused by coal dust inhalation that lead to permanent lung damage

[3] According to The National Institute of Occupational Safety and Health, USA (NIOSH), the permissible limit of Oxygen (O2) in coal mines is 18 % and higher than the threshold limit will increase fire intensity in underground coal mines while lower than 18 % will make suffocation and lead to deaths of coal mine workers.

mine workers are badly affected due to coal dust. Some of them even cannot perform their duties efficiently because one of the functionary parts of their body has been affected. Among these includes lung, kidney eyes, ear, nose, and throat etc. Azad, (2015) studied the impact of dumping the of coal mine residue on workers' health. He observed that the residual of coal mining (coal water and slurry), are disposed in unconfined area, resulting water and environmental degradation. Drinking of contaminated water by coal mine workers leads to multiple negative health impacts like ulcer, diarrhea, cholera, and hepatitis B etc. He refereed these problems to emission of different gases like coal dust, Methane (CH_4), Carbon dioxide (CO_2) and Carbon monoxide (CO) and Oxygen (O_2) beyond permissible level. We find only two studies conducted in Pakistan related to environmental pollution and coal mine workers health.

According to the literature review given above indicates and we observed that none of the study investigated the relationship between environmental pollution and health costs. There are many studies done to explore aspect of coal mining in different parts of the world. It is not sufficient to study the impacts of environmental pollution on health damages which does not indicate the monetary value of health damages of coal mine workers. According to our best knowledge, no study has investigated such relation earlier. Hence, present study is unique in its perspective because it will estimate the health costs of illness and will also investigate the determinants of total health costs (direct and indirect costs) of coal mine workers in district Duki, Balochistan. The costs of illness can be divided into two broad categories such as direct costs and indirect costs. Direct costs consists of travel costs, food costs, treatment costs, costs due to hospitalization, expenditures on medicine and doctors checkup fees, accommodation costs during visits to hospital and some other informal payments, while indirect costs consist of income reduction, decreased productivity due to missed work days/hours, loss of job, loss of time to seek job.

1.4 Area of the Study

This study will be conducted in Balochistan at District Duki. Balochistan constitutes 44% of Pakistan's total land. According to population census of Pakistan 2017, the total population of Balochistan province has 12.34 million people and it is growing at the rate of 3.37% per annum. This province is generously bestowed with natural resources, which includes chromites, coal, lead, iron, copper, gold, fluorite, marble and many other minerals as well. According to GSP (2012), 106 minerals are found in Balochistan and this province contributes 80% in the total amount of minerals that are being extracted in the country. World Bank Stated in its report that 39 minerals were being exploited from Balochistan in 2008. This indicate that a large number of minerals exist which are untapped yet. This could be due to poor infrastructure, economically non-viability of extraction, technological problems and social issues. However for future research it is important to investigate the major hurdles that could to improve income of the pronince. The mineral sector of province is potentially significant but underdeveloped. According to Balochistan Economic Report (BER, 2007), it is estimated that extraction of mineral resources generates an annual revenue of 3.4 billion and provides to employment to 1.3% of the total labour force. The major coalfield is Khost-Shahrig-Harnai (76 million tons), Duki (51 million tons), Sor-Range-Degari-Sinjidi (50 million tons) Mach Abegum (23 million tons of coal), Pir Ismail Ziarat (12 million tons).

District Duki is one of the underdeveloped areas of Balochistan. The population of District Duki is 0.15 million (census, 2017) and literacy rate is 30%. It is sub-divided into (08) union council. It is famous for coal mining and has second largest coal reserves, According to Inspectorate of Mines Loralai (2017), there are almost 6000 operational coal mines and amount of extraction is 4500 tons per days from these mines which is higher than other coal fields of Balochistan. These mines provide employment to approximately 40 to 50 thousand coal workers which belong to different districts of Balochistan, KPK and Afghanistan. Imperfection in labour market leads to exploitation of poor labourers because advance technology of extraction is not being used which provides more safety and health protection to workers. This is not only making the mining industry uncompetitive but also workers life at high risk As a result workers are suffering from different diseases and paying high costs in terms of health. Coal workers are working and living inside the coal field area without adopting any protection measure. At Distict Duki, coal workers are facing many problems like basic health facilities, decent working environment, skill, training and awareness about illness from coal mine pollution (dust). Present study estimated the cost of illness (respiratory illness, irritation of body, gastrointestinal problem, musculoskeletal harms & headache) and determinants of total health costs of coal mine workers (direct and indirect cost costs).

1.5 Research Questions of the Study

1. How the socioeconomic, demographic and environmental related factors affect the health costs of coal mine workers?
2. What are the direct and indirect health costs of coal mine workers?

1.6 Objective of the Study

The objectives of this study are to:

1. To investigate the impact of socioeconomic, demographic and environmental pollution on health costs of coal mine workers.
2. To estimate direct and indirect health costs of coal mine workers?
3. To develop policy suggestion from empirical findings of the study.

1.7 Hypothesis Testing

H_0: There is no significant difference between direct and indirect costs of illness of coal and non-coal workers.

H: There is significant difference between direct and indirect costs of illness of coal and non-coal workers.

Ho: Concentration level of environmental pollution (CH_4 and CO) does not have significant impacts on health costs.

H: Concentration level of environmental pollution (CH_4 and CO) have significant impacts on health costs.

1.8 Organization of the Study

The study is organized as:

Chapter one of the study covers the background, problem statement, significance, area of the study, research objectives research questions, and hypothesis testing of the study. Chapter two reviews relevant literature and chapter three deals with the data description and research methodology. While chapter four deals with result and discussion and last chapter of the study will explain conclusions and policy recommendations.

Chapter 2

Literature Review

2.1 Coal Mining and Health

Coal mining is an ancient occupation. The lifecycle of coal mine workers consist of coal exploration, mine development, mine operation and land rehabilitation. Coal mining is considered as the most hazardous occupation in health context. According to World Health Organization (WHO, 2005), Health can be defined as a state of complete physical, mental and social wellbeing of an individual and not merely the absence of disease and infirmity or Health is the extent to which an individual or a group is able, on one hand to realize aspirations and to satisfy needs and on the other, to change or cope with the environment. Coal mining hazards are in the form of physical, chemical, biological, ergonomic, psychosocial and environmental. Coal mining remains one of the most hazardous, dirty and difficult occupations compare to the other occupations. The health problems among coal miners range from short run to long run (Stephens and Ahern, 2001), which result high morbidity, mortality and economically bear higher health costs. In all levels of mining health risks occur due to dust exposure (Stephen and Ahern, 2001). The International Labour Standards (ILO) estimates that 2.02 million of people die each year from work related accidents and diseases. In economic terms, the ILO also estimates that 4% of world GDP is lost every year as consequences of occupational diseases and accidents.

2.1.1 Occupational Illness among Coal Mines Workers

Azad, (2015) conducted a study on the impacts of coal mining in Balochistan. The coal fields selected for study were Mach, So.range-Degari, and Chamalong coal fields. He collected data by primary source through questionnaire and secondary data was collected from (Mine and

Minerals department of Quetta), Environmental Protection Agency Quetta and hospitals, medical facilities from coal mine field's area. Due to high concentration of coal dusts in coal mine areas of Balochistan, different kinds of illness were found among coal mine workers. These health related problems were routine headache, shortness of breath, irritation in throat, nose, and eyes, drowsiness ,nausea, tuberculosis, pneumoconiosis ,chronic obstructive, respiratory irritation, heart problems, ulcer, diarrhea, hepatitis B and C ,cholera and lung cancer problems.

Another study carried out by (Ishatiaq et al., 2013) on the prevalence of occupational obstructive diseases among coal mines workers at district Nowshera. The study consisted on cross sectional data from January 2013 to July 2013 and selected 400 coal miners, having 6 months' work experience of underground coal mining. According to medical reports of pulmonary function tests and chest X-rays of coal mines workers, it is concluded that the prevalence of the occupational obstructive diseases was high among coal mines workers at Cherat, district Nowshera.

Ishatiaq et al., 2014) also conducted a study on frequency of occupational health problems among coal mines workers of Khyber Pakhunkhwa, Pakistan. It was a cross sectional study from July 2012 to June 2013 and the sample size consists of 400 coal miners. The data was collected from primary sources through questionnaire. The descriptive statistics of the study were that more than half of coal mines workers suffered from various sign and symptoms of occupational illness of coal mining. The various frequencies of occupational health problems including Respiratory system (n=209), irritation of nose & throat (n=134), dermatological (n=167), musculoskeletal (n=243), eye problems (n=140), gastrointestinal (n=191), nervous system (n=91), ear problems (n=116) and many other diseases also prevail among coal miners. So, it was concluded that every systems of the body was badly affected due to coal mining.

Laney et al., (2014) presented a literature review for an update on respiratory diseases caused by coal mine dust. The literature review was the result of an international conference on occupational and environmental lung disease held in summer 2013 at Morgantown, USA. Coal mine dust causes a spectrum of lung diseases collectively termed as coal mine dust lung disease (CMDLD). The different kind of lung diseases are Coal Workers Pneumoconiosis (CWP), mixed dust pneumoconiosis, chronic obstructive pulmonary disease, dust related diffuse fibrosis and coal miner's silicosis. The conclusion of the report was that, coal miner's remains at risk because coal dusts remain a relevant occupational hazard for coal mine workers working in underground coal mining.

Hendryx, 2008) carried out a study on mortality from heart, respiratory and kidney disease in coal mining areas of Appalachia, USA. The study consisted on secondary data, cross sectional data from 2000 to 2004 and Poisson regression model were applied to compare the mortality rate among population of Appalachia. The population was divided into four exposure groups: no mining, non-Appalachian mining, Appalachian mining up to 4 million tons and Appalachian coal mining greater than 4 million tons of coal production. The study concluded that chronic heart, respiratory and kidney disease mortality rates were significantly higher in coal mining areas of Appalachia compared to non- mining areas of the country. The prevalence of occupational diseases amongst coal mines workers was alarming. Pneumoconiosis is a lung disease resulting from chronic exposure to coal dust, its inhalation and deposition. There are many factors responsible for such a devastating situation of coal miners that are poor hygienic condition, traditional coal mining practices, lack of personal protective equipment's and odd working hours for coal mining workers.

The most common disease prevails among coal mine workers is Coal Worker’s Pneumoconiosis (CWP). Coal worker’s pneumoconiosis is a lung disease caused by the inhalation of coal mine dust. The happening of CWP and its rate of progression are correlated to which coal mine workers were exposed during their working time in underground coal mining. Antao et al., (2005) conducted a study on coal worker’s pneumoconiosis (CWP) of United States coal mine workers. The aim of the study was to identify the progressive coal mine pneumoconiosis and factors related to disease such as geographic distribution and other associated risk factors. A cross sectional study from 1996 to 2002 and 29521 coal mine workers were examined. A total of 886 cases of coal workers pneumoconiosis (CWP) were identified among total miners. The study further investigated subset of 783 miners having CWP, whom progression have been elevated. The result shows that 277 (35.4 %) coal miners were having rapidly progressive CWP and including 41 miners having (Progressive Massive Fibrosis 9PMF), a type of CWP disease. It was also analyzed that CWP was varied on geographic distribution and inadequate prevention measures were the associated risk factors among coal mine workers.

2.2.2 Cost of Illness

Cost-of-illness studies measure the economic burden of a disease or diseases on individual’s life, society and also on the whole nation. Costs are classified into four different types such as direct cost, indirect direct, intangible cost and total costs (Razzouk, 2017). A study conducted by (Satti et al. 2015), using Pakistan panel household survey for 2010 and cost of illness methodology by measuring health and economic consequences of overweight and obesity among Pakistani adults. The findings of the study show negative relationship between weight and health. The study further analyzed the high prevalence of disease in those adults who were having high weight. While the annual direct and indirect costs of overweight and obesity adults was o.4 and 1.9 % of country's GDP.

Mehwish and Mustafa, (2016) carried out a study to estimate the impact of the dust pollution on worker's health and cost of illness in the textile industry of the Faisalabad by using cross sectional data. 200 textile workers were randomly selected and Structural Equation Model (SEM) was used for study. The finding of the study showed that 62 % worker's suffered from cost of illness and 43 % workers miss the for last two weeks. 69 % workers were not normal in performance during work due to illness. It was noticed that the prevalence of respiratory disease was high among textile workers. The study also estimated that 30 % workers suffered the health cost between 1 to 1500 rupees, 15 % in the range of 600 to 1000 and 15 % among 1100 to 200 while 2.5 % between 2100 to 2500 in the last two weeks. 41 % of textile workers bear the opportunity cost in the range of Rs. 500 to 1500.

Leigh et al., (200) conducted a study in the USA, to estimate cost of occupational injuries and illness. The estimated direct costs in terms of medical care cost that include doctor fee, nurse fee, diagnostic test cost, hospitalization charges, medicine cost etc. on the other hand indirect costs included loss of wages/productivity due to off work days and partial off days.

A study was carried out by (Paul et al., 1997) to estimate the direct and indirect cost of occupational injuries and illness in the USA in 1992. The data was collected from Bureau of labour statistics and applied a risk proportion method. While for estimating total cost, the human capital method was used. The estimated direct cost was ($65 billion) and indirect cost was ($106 billion, so the total costs were ($171 billion). However intangible cost was not included in the study because it cannot be measured in monetary values.

2.2 Coal Consumption and Economic Growth

As we know coal extraction and consumption has strong relationship with economic growth of a country. Coal is the principal source of energy generation in the world because coal is the most affordable, economical and abundant source of energy. The demand of coal will increase in future (Wolde-Rufael, 2010). Satti et al., (2013) carried out a study to revisit the casual relationship between coal consumption and economic growth in case of Pakistan. The study consisted on time series data from 1974 to 2010 by applying VECM Granger causality approach. The estimated result show that there is exists bidirectional causal relationship between coal consumption and economic growth.

Another study conducted by (Shahbaz et al., 2012) reinvestigated the casual relationship between coal consumption and economic growth in case of Pakistan. They have used endogenous two-break unit root and the ARDL bounds testing approach to examine long term relationship between the variables. The study consisted on time series data from 1971 to 2009. Their result showed the presence of long term relationship among variables and also noted that coal consumption, labour and capital are contributing factors to economic growth of Pakistan.

Baloch et al., (2011) carried out a study on coal consumption, CO2 emission and economic growth in China. The study investigated the relationship between coal consumption and economic growth using both supply-side and demand-side frameworks. The result indicated that there is a unidirectional causality from coal consumption to economic growth both in short and long run under the supply0-side analysis, while there is also a unidirectional causality from income to coal consumption in the short and long run under the demand-side analysis.

2.3 Environmental Degradation due to Coal Mining

According to the reports issued by World Health Organization (WHO) in 2008 and by environmental group 2004 , coal particulates pollution are estimated to shorten approximately 1,000,000 lives annually worldwide. The impacts of mining activities on water, soil quality, land, forests, ecosystem, habitation of wildlife, pollution of air, marine and aquatic lives and on human health need serious concern (Sahu and Dash, 2011). The coal mining activities such as searching, expansion, extraction, concentration, processing, modification and deactivation have different impacts which consist of air pollution, water pollution, soil degradation etc (McAllister et al., 2000). Coal mining badly affected socio-economic activities and environment causing a high level of pollution and reducing the water quality (Milioli, 1999). Production of coal is an important input and fuel that powered the Industrial Revolution for progress and development, which transformed the economies and societies over the last two centuries. However, damages of coal production and consumption were ignored for long period. Extraction of coal and using it for energy generation produced emissions that build up the greenhouse effect more hazardous. Coal production and consumption in industries is one the biggest source of climate change. The average global temperature has risen by 0.85 degree Celsius since temperature recorded began and the mean sea level has risen by 19 cm since 1901 (Coal Atlas,2015).

Coal extraction has huge impacts on the environment. Due to coal mining extraction and production operations, different poisonous gases such as methane (CH_4) and carbon dioxide (CO_2) released into air and resulting global warming, air pollution and caused greenhouse effects (Eyre et al., 1998). Coal dust is responsible for number of diseases and health degradation (Steffen et al., 2005). Moschini-Carlos et al., (2011) conducted a study which was titled as impact of coal mining on water quality. Three different lakes were selected for sample size near the south region of Sanata Catarina State (Brazil). Chemical and physical aspects of water quality were analyzed and dissolved nutrients concentration of water was filtered in situ through a Whatman GF/C47 mm membrane. All lakes showed high concentration of chemical composition and was concluded that coal mining activity and waste disposal (coal water and slurry) have drastically affected the water quality. It was made all lakes inappropriate for different human use like swimming, fishing and for leisure time.

Azad, 2015) conducted a study on the impacts of coal mining in Balochistan. The study consisted on cross sectional data from May 2008 to April 2009 and two types of data primary and secondary data were collected. Primary data was obtained through questionnaire and secondary data were obtained from (Mine and Mineral department of Quetta and Environmental Protection Agency (EPA), Quetta). Three different coal fields were selected for the study, that were Mach,So- range-Degari and Chamalong. The study concluded that average emission and prevalence of methane (CH_4), carbon monoxide (CO) and oxygen (O_2) measured as 11.8m3/ton, 36ppm and 14%, which exceeded the standardized level given by National Institute of Occupational Safety and Health (NIOSH), USA. The permissible limits recommended by NIOSH are 1-10m3/ton, 30ppm and 18%, however the higher concentration of poisonous gases and coal dust is not only reason of illness among coal miners but also causing severe harm to the environment. The cutting of trees, removing of plants, herbs and tope soil from the irrigated and non-irrigated area for coal mining has destroy the forests, agricultural land and natural wildlife habitats.

2.4 Impacts of Coal Mining on nearby Communities

Coal mining, coal extraction and coal consumption not only have short and long term impacts on worker’s health but also have effects on environment, biodiversity and surrounding area of the coal mining due to coal dust and coal wastes known as slurry. Ashraf et al., (2016) analyzed the public pedagogy in coal rich areas of Pakistan and China and concluded that those people who are using the coal as a business are becoming richer and richer but the people who live in these areas are suffering from the environment and health problems. People from these areas are not getting quality and equal education, health facilities and proper environmental and health education etc.

Coal mining activities near residential area has hazardous impacts on newly born child. A study conducted by (Ahern et al., (2011) on the residence in coal mining areas of West Virginia, USA. The aim of the study was to assess the relationship between residence in coal mining environment and low-birth-weight outcomes. Study consisted on a cross sectional data from 2005 to 2007 and sample size was (n = 42,770), using retrospective analysis and nested logistic regression to conduct the study. The result indicated low-birth-weight by 16% with high level of coal mining activities as compared to 14 % low-birth-weight in low levels of coal mining activities. The above literature indicates that coal mining has hazardous impacts on miners working in underground coal mines.

Chapter 3

Data Description and Research Methodology

This chapter is divided into two main parts, first part consists on data description and the second part consists on methodology and empirical specification.

3.1 Sources of Data Collection

Primary data is collected from coal mine workers from District Duki, Balochistan through questionnaire by exploring worker's illness (respiratory illness, irritation, gastrointestinal problems, musculoskeletal harms and headache) and also estimating costs of illness (direct and indirect costs). Concentration level of Poisonous gasses (Ch_4, CO) and thresholds limits of oxygen (O_2) in coal mines are estimated by gas device known as multi gas detector. Theses poisonous gases and thresholds limit of O2 is recoded at the place where coal workers extract coal from coal seam[4].

For comparing cost of illness, there are two groups of workers known as treatment group and control group.

- Treatment group workers are those workers who work in extracting coal mines. Present study focused on workers who involved in extracting underground coal mines. Only those workers

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[4] **Coal Seam** is a dark brown or black banded deposit of coal that is visible within layers of rock. These seams are located underground and can be mined using either deep mining or strip mining techniques depending on their proximity to the surface As well, these seams can act as an unconventional source of natural gas. When natural gas is obtained from a coal seam, it is known as coal seam gas. This gas bonds to the surface of underground coal seams, which are generally filled with water. The pressure of this water makes the gas form a thin film on the surface of the coal. The level of gas bonded to the coal seam depends on the thickness of the coal, the depth of the coal, and the permeability.

are included in the samples that have more than 6 months working experience in coal mines. So that they have sufficient exposure of coal dust and other gases, affecting their health.

- ❖ Control group workers are those who work somewhere else in different environment than coal mines and their working hours are similar to coal mine worker and have same social, cultural, demographic and economic characteristics similar to coal mine workers. So that cost of illness and frequency of illness can be compared. This study compared coal workers cost of illness, frequency of illness with construction workers, farmers and hotel workers. Because they have also risk of illness in their occupation such as lack of protective measures, overtime working duties, lack of awareness, lack of basic health facilities, and risk of accidents etc.

3.2 Sampling Design

The total sample size is 300 (n=300) workers, in which 150 workers are taken from coal mines working in underground coal mining known as treatment group and 150 labour are selected from control group. Due to lack of resources and time constraint, 150 coal mine workers are selected from 30 coal mines and 5 coal workers are selected from each coal mine. The 150 coal workers are further divide and choose from three different types of coal mine having different size of coal seam like 3 feet, 5 feet and 9 feet in width. So, 50 coal workers are selected from each type of coal mines. It is because concentration level of poisonous gasses (CH_4, CO), coal dust, and different threshold limits of oxygen (O_2), frequency and costs of illness of coal workers could vary across different coal seam. Workers from control group consisted on three different occupations, that are farmers, construction workers and hotel industry workers (waiters) and 50 labours from each occupations are selected having similar socio economic, demographic and cultural background like coal mine workers has.

Selection of Treatment Group by Stratified Random Sampling Method

Coal Mines and Coal Workers	Coal seam having 3 feet width	Coal seam having 5 feet width	Coal seam having 9 feet width	Total Coal Mines and Coal Workers
Coal Workers	10*5=50	10*5=50	10*5=50	30 Coal Mines and 150 Coal Workers

Selection of Control Group by Stratified Random Sampling Method

Mixed Workers	Farmers	Construction Workers	Hotel Industry Workers	Total Workers
Workers	50	50	50	150

3.3 Conceptual Framework of the Study

The conceptual framework (figure, 3.1) of the study shows the impacts of coal extraction from underground mines on coal worker’s health and their environment. The long term impacts of coal extraction on worker’s health is in the form of worker’s illness like respiratory illness, irritation, gastrointestinal problems, musculoskeletal harms, headache etc. Coal dust, coal slurry, underground coal water and flowing of warm air in mines have also short term impacts on worker’s health during coal extraction. The environmental factors are the poisonous gases like CH_4, CO, CO_2 and H_2SO_4 effecting worker’s health badly and often death of workers and fire in mines occurred due to these poisonous gasses. So, worker’s health is affected both by illness and poisonous gasses during coal extraction.

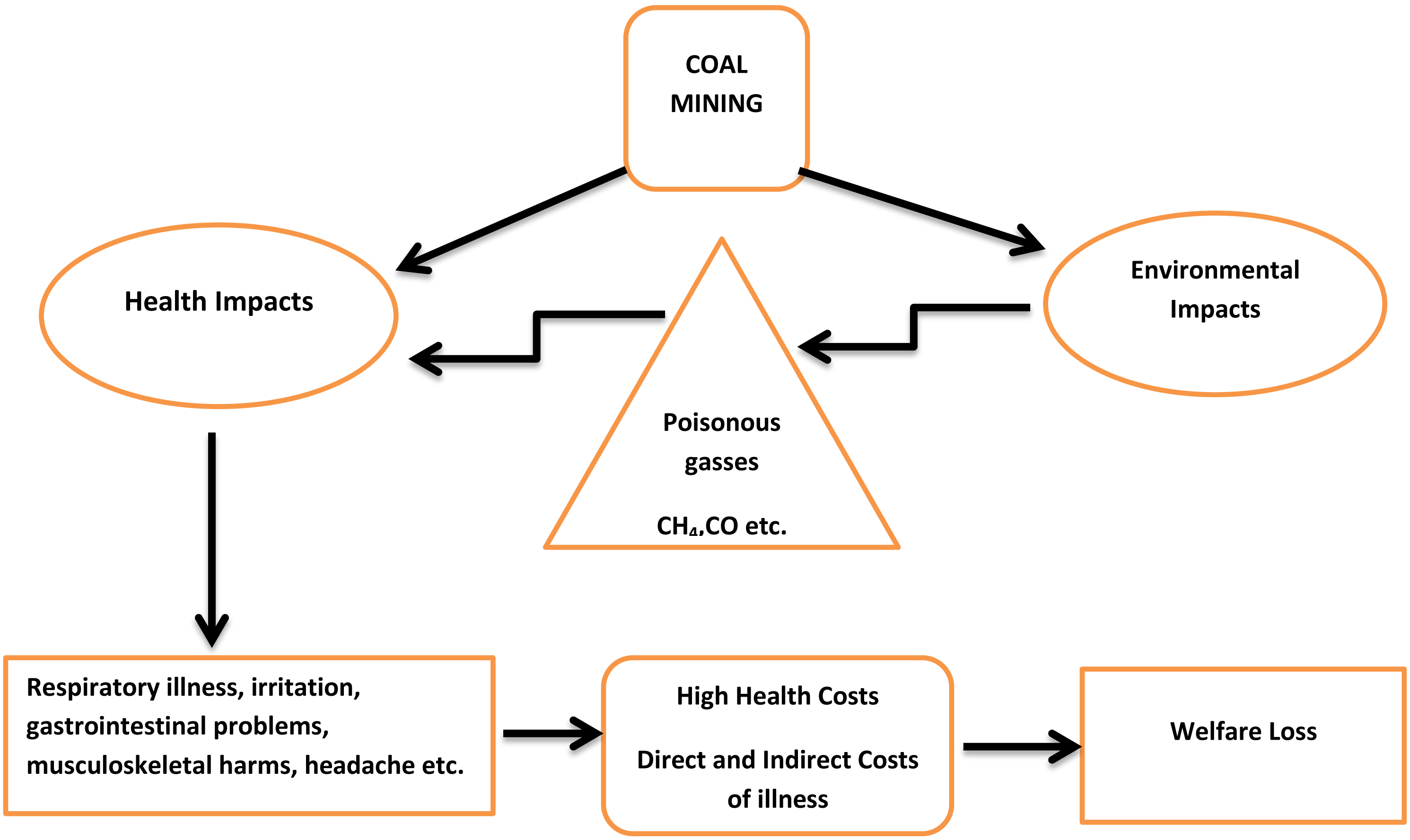

Figure 3.1 Impact of coal mining on workers' health (Author own constructs)

Estimating Costs of Illness (COI)

Cost of illness measure the economic burden of a disease. Cost of illness studies has much importance to estimate the maximum amount that could be potentially saved or gained if a disease were to be cured or eradicated. There are two main types of cost which measures costs of illness that are direct and indirect cost.

Direct costs measure the opportunity cost of resources used for treating a particular illness such as Respiratory illness, irritation of body, gastrointestinal problems, musculoskeletal harms, and headache. Direct cost consists on diagnostic tests costs, costs due to hospitalization, expenditures on medicine and doctors checkup fees, accommodation costs during visits to hospital and some other informal payments. Opportunity cost can be defined as "the value of the forgone resources that are used or lost due to illness".

Indirect costs measure the value of resources lost due to particular illness. indirect costs consists of income reduction, decreased productivity due to missed work days/hours, loss of job, loss of time to seek job, uptake of less paid labour due to illness. There is also a third type of costs known as intangibles costs which consists of pain, suffering which can't be measured in monetary values. So, the present study will only estimate the direct and indirect cost of illness of coal mine workers and control group workers.

3.5 Approaches to measure the Costs of Illness

There are four important approaches for measuring the cost of illness. These approaches are (a) The Human Capital Method (HCM) (b) The Willingness to Pay Model (WTP) (c) The Production Function Approach (PFA) (d) The friction Cost Method(FCM). Present study will use Human Capital Method for estimating costs of illness of coal worker's because it has some importance over other approaches. Willingness to pay is not equal to ability to pay for the poor, because they might be willing to pay but unable to pay (Russel, 1996). Production function has not been used much for estimating cost of illness because it does not estimate direct costs of a disease or illness. The friction cost method takes only the viewpoint of the firm and society. Therefore FCM is not useful technique for estimating cost of illness on a workers level. While HCM estimates the cost to society of loss productivity, discounted to present values. The productivity losses associated with illness, morbidity and mortality as the "market value" of that individual's future contribution in a society if he/she had continued to work in full health. HCM is also known as “Top-down-approach (Gross costing method) and it estimates direct and indirect costs of illness.

3.6 Methodology

Theoretical framework of the Study

We the help of previous literature by Freeman (1993), Dasgupta (2001), Murty et al. (2003), Dasgupta (2006), Chodhery et al. (2010) and Adhaikari (2012), the production health function for coal mine workers is given below

$$H= H (Q, M, A; Z) \quad (1)$$

Where,

“H” shows the health condition taken as frequency of illness of five different diseases i.e. respiratory illness, irritation of body, gastrointestinal problems, musculoskeletal harms and headache caused by pollution (Q) due coal extraction. “M” indicates mitigating activities like getting treatment either self or from doctor, taking medicine, diagnostic tests, hospitalization etc. while “A” refers averting behavior (activities) of coal mine workers by taking rest in homes, using protecting measures (proper mine dress, gloves, helmet etc.) to protect themselves from different illness and higher cost of health due pollution inside coal mines. Here, “Z” shows coal mine characteristics of their health.

The utility function is given below

$$U= U (X, L, H, Q) \quad (2)$$

“X” shows consumption level of other commodities, “L” indicates leisure time, while “H” refers health condition of coal mine workers and “Q” is level of pollution due to coal extraction.

The budget constraint is given below

$$Y = Y^* + W^* (T-L-H) = X + P_a A+ P_m M \quad (3)$$

Where "W" refers wage rate, Pa and Pm are the costs of averting and mitigating activities of coal mine workers. The price of the aggregate consumption "X" normalized to one, Y* is the non-wage income, while W* (T-L-H) is the income earned by coal mine workers from other sources give total income.

To maximize the utility function with respect to X, L, A and M subject to budget constraint. The first conditions for averting and mitigating activities has the following demand function.

$$A = A\,(W, P_a, P_m, H, Q, Y, Z) \tag{4}$$

$$M = M\,(W, P_a, P_m, H, Q, Y, Z) \tag{5}$$

From equation (1) to (5), we can derive Willingness to pay (WTP) function for coal mine workers due to change in the level of pollution during coal extraction. As we know the opportunity cost, costs of treatment, costs of averting activities and the monetary value of disutility causes by different illness is due to coal mine pollution. We can report this in the following function

$$\text{WTP} = w\frac{dH}{dQ} + Pm\frac{dM}{dQ} + Pa\,\frac{dA}{dQ} - \,\frac{Uh}{\lambda}\,\frac{dH}{dQ} \tag{6}$$

Suffering and pain are quantitatively difficult to estimate; therefore we want to capture the benefit from a reduction of pollution inside coal mines through given equation

$$\text{WTP} = w\frac{dH}{dQ} + Pm\,\frac{dM}{dQ} + Pa\,\frac{dA}{dQ} \tag{7}$$

Cost of averting activities is difficult to measure accurately, so we use cost of illness (COI)

$$\text{COI} = w\,\frac{dH}{dQ} + Pm\,\frac{dM}{dQ} \tag{8}$$

Equation (8) estimates the lost earning (opportunity cost) of working off days, off partial days and treatment costs of illnesses.

3.6.1 The Double-hurdle Model (DH)

The Double-hurdle model originally proposed by a Canadian statistician Cragg (1971) and later developed further by Mullahy (1986). Cragg assumes that two separate hurdle must be passed before a positive level can be observed. With a Double-hurdle model there are two tiers contributing to a process. First tier of the model shows the decisions to do something and explains this in term of binary decision. Second tier of the model shows intensity of doing something of the first tier. In case of coal mining, a Double-hurdle model is used to solve simultaneously workers decisions of getting treatment (either self or from doctor). It is binary decision whether to spend something on treatment or not. The second tier of the model shows the intensity of workers total costs (direct and indirect costs) of visiting doctors for better treatment. The decision of getting treatment and intensity of costs depends upon many influencing factors like economic, social, cultural, demographic and environmental.

Yu and Abler (2007) employed Double-hurdle model to investigate the participation decision in smoking and consumption on smoking. Dinar (2017) used double hurdle model to explore the decision to select bottled water and the level of consumption on bottle water. Ekains, (2009) employed double-hurdle model to find out household decision to purchase energy and the decision of how much to purchase. Humphrey and Ruseski, (2010) explored the economic choice of participation and time spent in physical activity and sport using. Eakins, (2014) used double-hurdle model to know about household expenditure decision on petrol and diesel. Essein et all. , (2012) carried out a study on fertilizer adoption and optimum use by farmers using double-hurdle model. Kouser et all, (2017) used DH technique and argue that adaptation of Bt technology can reduce employment of poor workers. Shahzad and David J. (2018) also use double-hurdle model to estimates the impact of relationship between Bt adoption and health cost of farmers.

For this study double-hurdle model will be used for workers decision to get treatment either self or from doctor and its intensity of total costs (direct cost and indirect cost). Direct cost consists on diagnostic tests costs, doctor fee, cost costs of hospitalization and accommodation, medicine cost, travel cost, food cost and indirect consists on working off days and partial off days due to illness. The double- hurdle model will be employed for each illness (respiratory illness, irritation of body, gastrointestinal problems, musculoskeletal harms and headache) of worker's.

First tier is binary decision which is expressed as,

$$d\dot{h}_{ij} = rx_{ij} + u_{ij}: \qquad u_{ij} \sim N(0,1) \qquad and \qquad d\dot{h}_{ij} = \begin{cases} 1\ if\ d\dot{h}_{ij} > 1 \\ 0\ otherwise \end{cases}$$

Where $d\dot{h}_{ij}$ is latent variable for dh_{ij} which is equal to one if the worker decides to get treatment either self or from doctor will be considered 1, otherwise zero. Here, "i" stands for ith respondent (i=1, 2, 3 ….150) and j stands for j^{th} sickness (j=1, 2, 3 ….5).

Where dh_{ij} is dependent variable and its shows worker's decision for treatment either self or from doctor and it depend upon many independent variables (X_i) which are given below

X_1 = Age of the respondents (no. of years)

X_2 = Education level (number of years)

X_3 = Income of respondents (Rupees)

X_4 = Nationality of the respondents (local worker =1, otherwise 0)

X_5 = Working hours (number)

X_6 = Age when work started (number of years)

X_7 = Wage rate (rupees per day)

X_8 = Distance from medical treatment (kilometer)

X_9 = Frequency of illness (number of times)

X_{10} = Living condition (sleeping place) (1= improved, 0 = not improved)

X_{11} = Sources of water (1= safe source, 0= not safe source)

X_{12}= If respondent working in coal mine then (D =1, otherwise D = 0)

The second tier of the double- hurdle model can be expressed as,

$$Q\dot{h}_{ij} = \beta z_{ij} + v_{ij}: \qquad v_{ij} \sim N(0, \sigma^2) \qquad and$$

$$Q\dot{h}_{ij} = \begin{cases} Q\dot{h}_i \ if \ Q\dot{h}_{ij} > 0 \ and \ d\dot{h}_{ij} = 1 \\ 0 \ otherwise \end{cases}$$

Here $Q\dot{h}_{ij}$ *is* latent variable for Qh_{ij} represents total treatment cost (direct and indirect costs). Also, x *and* z are vectors of covariates that may overlap or also differ? γ *and* β are vectors of parameters to be estimated and u_{ij} *and* v_{ij} are random error terms.

Where Qh_{ij} is a dependent variable known as total direct costs of each illness (respiratory illness, irritation of body, gastrointestinal problems, musculoskeletal harms and headache) and it depend on different independent variables which are given below. The z includes the following variables.

Qh_{ij} = Cost of illness of coal mine workers due to illness (Rs. / last 6 months

Z_1= frequency of getting treatment for each illness (Respiratory illness, irritation of body, gastrointestinal problems, Musculoskeletal harms & headache) either self or from doctor within last six months. (1= getting treatment either self or from doctor, 0= not getting treatment)

Z_2 = Age of the respondents (no. of years)

Z_3 = Education level (number of years)

Z_4 = Income of respondents (Rupees)

Z_5 = Nationality of the respondents (1= local worker, 0= migrant)

Z_6 = Working hours (number)

Z_7 = Age when work started (number of years)

Z_8 = Wage rate (rupees)

Z_9 = Distance from medical treatment (kilometer)

Z_{10} = Frequency of illness (number of times)

Z_{11} = Living condition (sleeping place) (1= improved, 0 = not improved)

Z_{12} = Sources of drinking water (1= safe source, 0= not safe source)

Z_{13} = Concentration level of methane (%)

Z_{14} = Concentration level of carbon monoxide (ppm)

Z_{15} = Thresholds limit of oxygen (%)

Z_{16} = Width of coal seam (unit of measurement, feet)

Z_{17} = Length of coal mine (unit of measurement, feet)

Z_{18} = If respondent working in coal mine then (D =1, otherwise D = 0)

3.6.2 Brief explanations of different Variables

Costs of Illness

Costs of illness consists on health cost (direct cost) and opportunity cost (indirect cost), while intangible cost consist of pain due to illness but it could not measurable in monetary values. So, this study will estimates direct and indirect costs of worker's illness. The direct cost consists of diagnostic test cost, doctor fee, cost of hospitalization and accommodation, cost of medicine, food and travel cost while indirect cost consists of work days off and partial off days.

Frequency of Illness

Frequency of illness means that how much of each disease occurred within last six months.

Quality of Water

It refers quality and sources of water, where a worker uses water for drinking and other purposes.

State of Residence

By state of residence we mean that how much safe and cleaned the nearby areas or surrounding of a worker where he eats, drinks and lives.

Methane (CH_4) Concentration Level

Methane (CH_4) is odorless and colorless gas, which is lighter than air. Its detection is very important to know about it concentration level in coal mining. Methane gas is flammable and lead explosions in coal shifts, the gas trapped in the rock can be released as a result of coal mining. Methane gas in the coal mining is dangerous because higher concentration of methane reacts with air and displaces the prevalence of oxygen (Antao et al., 2005). Higher level of methane concentration leads suffocation and ultimately sudden death (Walter et al., 2001). Methane gas detection was first used in 20^{th} century by coal mine workers who used canary birds that pass out if there were any spike in the amount of methane in the atmosphere (Thomas and Haider, 2014). Methane emission from coal mining depends on the mining method, depth of coal mining, coal quality and entrapped gas content in seams and coal rocks (Watson et al., 2004). A

Multi gas detector is a tool/device used for detecting the concentration level of methane gas in coal mining. The permissible limits of methane by National Institute of Occupational Safety and Health (NIOSH, USA) are 1-10m3/ton or 0.05%.

Concentration Level of Carbon monoxide (CO)

Carbon monoxide (CO) is often called the "silent killer" because of its ability to take lives quickly and quietly**.** Co is a colorless, odorless, tasteless and non-irritating which is highly toxic to humans. It is produced from incomplete combustion or explosion of substance having carbon such as coal, natural gas etc. CO is so dangerous to humans because it is so readily observed by the blood even more than oxygen. Highly active tissues of oxygen metabolism, such as brain, liver, heart, muscle, and kidney are particularly sensitive to CO concentration level (Wei-Long et al., 2003). Environmental CO exposure is typically less than 0.001% or 10 ppm. The permissible limit of CO in coal mining is 30ppm (NIOSH, USA).

Threshold limits of Oxygen (O_2)

Oxygen is a colorless, odorless and tasteless gas. Oxygen occurs in the air as a gas and makes up approximately 21 % of the air we breathe. Oxygen is essential for life and it takes part in the process of respiratory system of the human body, which makes it important for living life. The recommended threshold limit by NIOSH is 18% in coal mining. Because O_2 higher than 18% will help CH_4 to increase fire intensity in coal mine and lower than18% will create suffocation and sudden death of workers occurred.

Age of Workers

It is expected that old age workers would suffer more from illness and facing high costs of illness as compared to young coal mines workers. While increasing age brings more experience and familiarity with working environment (Margolis, 2007).

Working duration/ Duty hours

It refers duty hours of a worker per day or a week. It would be expected that more duty hours or overtime will increase the intensity of illness and costs of illness.

Income of Workers

This refers to worker monthly income in PKR.

Width of Coal Mine Seam

This refers to the width of seam of coal mines. It is expected that illness, frequency of illness and cost of illness would be high in large size coal mines.

Length of Coal Mines

This refers to the length of coal mines in feet.

Chapter 4

Results and Discussion

This chapter consists of Descriptive statistics and Econometrics Analysis of five different diseases (respiratory illness, irritation of body, gastrointestinal problems, musculoskeletal harms and headache) both for Treatment and Control group.

4.1 Descriptive Statistics of different illnesses

The frequency distribution of respiratory illness for coal mine workers and non-coal workers is shown in figure 4.1. In the first group of frequency distribution where 23% of coal mine workers and 69% of non-coal workers are getting sickness between zero to 10 times during last six months. In the second group 17% respondents from both groups get sickness between 11 to 20 times. Now if we look figure 4.1 more deeply, we can see as we move from left to right, the percentage of respondents are decreasing for non-coal workers and increasing for coal mine workers. The average frequency of respiratory illness for coal mine and non-coal workers is 26.04 and 7.56 times, respectively during the last six months. The average visits to get treatment either self or from doctor for coal mine and non-coal mine workers are 2.18 and 0.65 times, respectively during the last six months. This implies that coal mine workers are facing more respiratory problem than non-coal workers.

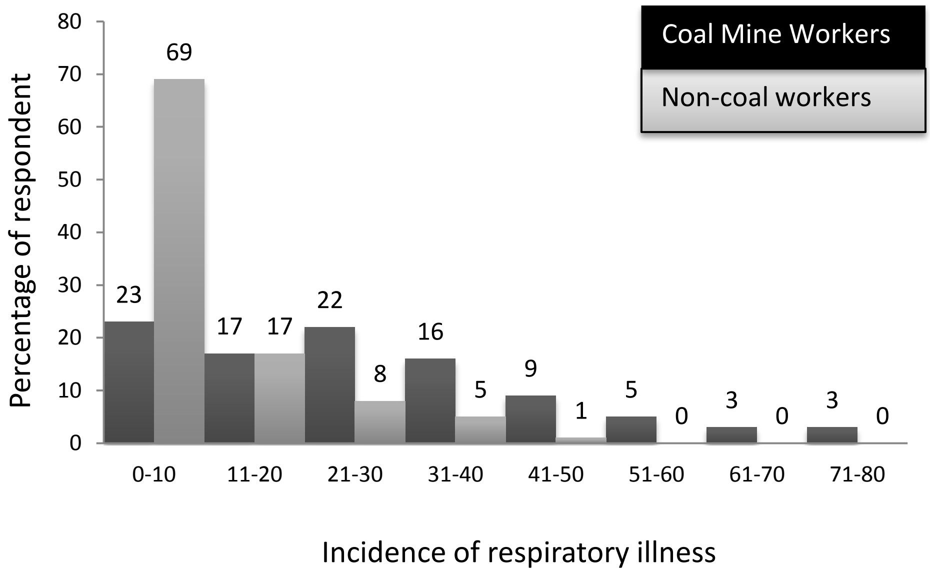

Figure 4.1 Frequency distribution of respiratory illness of coal and non-coal mine workers

The total direct costs of respiratory illness of coal mine workers and non-coal workers are represented in Figure 4.2. We can clearly observe from the first group where 45% and 80% of coal mines and non-coal mine workers, respectively are facing directs cost of respiratory treatment in the range of 0 to 3000 rupees during the last six months. In the 4th frequency group where 7% and 0% of coal mine and non- coal mine workers, respectively are facing direct costs in the range of 9001 to 12000 rupees for six months. The average costs of respiratory illness of coal mine and non -coal mine workers is Rs.4642 (79%) and Rs.1267 (21%), respectively. This clearly indicates that coal mine workers are facing higher direct costs of respiratory illness than non-coal workers.

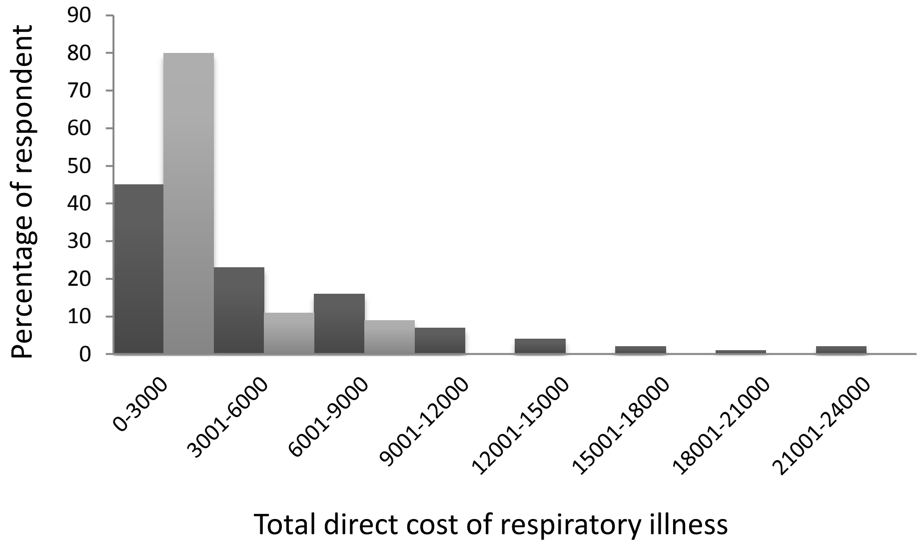

Figure 4.4 Comparison of total direct costs in percentage of coal mine and non-coal workers

Frequency distribution for irritation of body is shown in figure 4.3 and it clearly shows that 72% of coal workers and 83% of non-coal mine workers are getting sickness between 0 to 10 times for last six months. In the 4th group of frequency distribution where 10% of coal mine workers and 0% of non-coal workers sickness is in the range of 31 to 40 times for last six months. The average frequency of coal mine and non-coal workers are 14.53 and 4.14 times, respectively during last six months. This clearly indicates that coal mine workers are more suffered from irritation of body than non-coal workers.

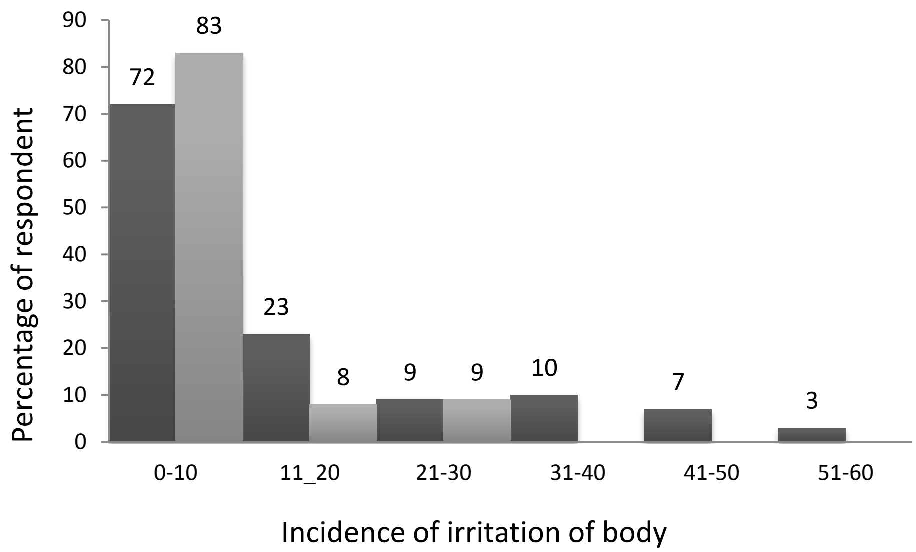

Figure 4.3 Frequency distribution for Irritation of body of coal mine and non-coal workers

The total direct costs for irritation of body is represented in figure 4.4 and it clearly indicates that in the first 71% and 90% of coal mine and of non-coal workers, respectively are facing direct costs of irritation treatment in the range of 0 to 2000 rupees during last six months. While 3^{rd} frequency group indicates that 3% and 1% of coal mine and non-coal workers direct costs is between 4001 to 6000 rupees, respectively during last six months. We can clearly see from left to right that the percentage of direct costs of health are decreasing for non-coal workers and increasing for coal mine workers. The average direct costs of irritation of body for coal mine and non-coal workers are Rs.2146 and Rs.447 respectively for last six months. This implies that coal mine workers are facing higher direct costs of irritation of body than non-coal workers.

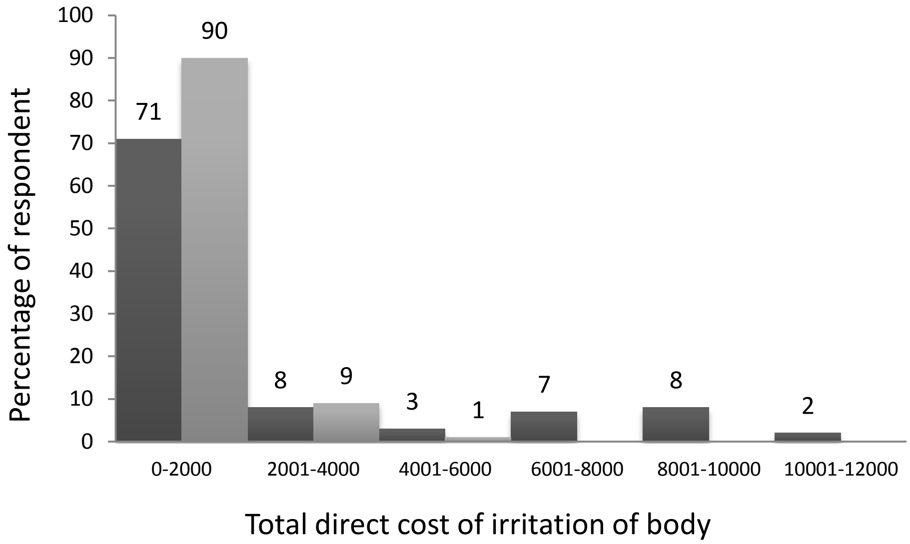

Figure 4.4 Comparison of total direct costs in percentage of coal mine and non-coal workers

The frequency distribution for gastrointestinal problems of coal mine and non-coal workers are shown in figure 4.5. We can clearly observe from the first group where 20% and 17% % of coal mine and non-coal workers are getting sickness between 0 to 5 times, respectively for last six months. In the 8th group where 13% and 3% of coal mine and non-coal mine workers sickness in the range of 36 to 40 times, respectively for last six months. The average frequency of gastrointestinal problems is 22.24 and 7.74 times, respectively coal mine and non-coal worker. This implies that coal mine workers are facing more gastrointestinal problems than non-coal workers.

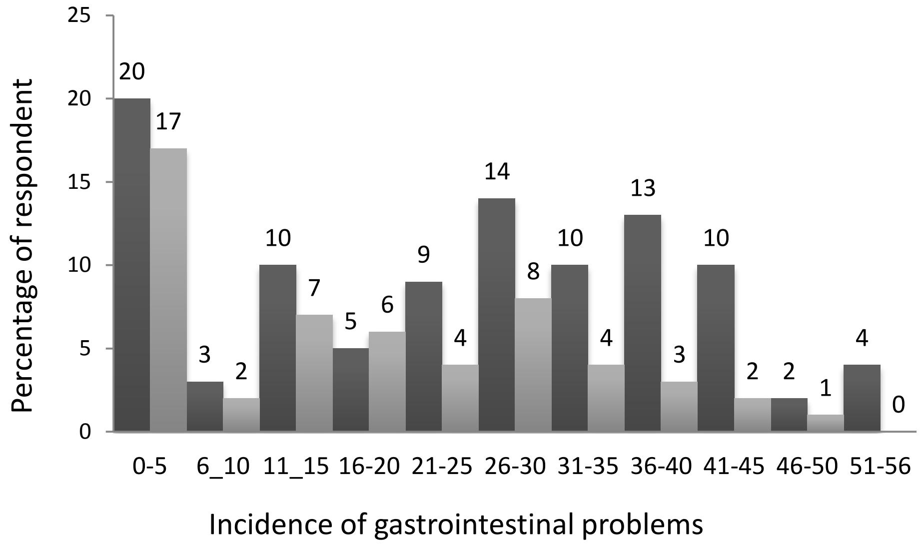

Figure 4.5 Frequency distribution of gastrointestinal problems of coal mine & non-coal workers

Total direct costs of gastrointestinal problems of coal mine workers and non-coal workers is shown in figure 4.6. It can be clearly observed from the first group where 30% and 28% of coal mine and non-coal workers respectively are facing total direct costs of gastrointestinal treatment in the range of 0 to 2000 rupees for last six months. We can see from left to right that the percentage of direct costs are decreasing for non-coal workers and increasing for coal mine workers. The average direct costs of coal mine and non-coal mine workers are RS.4948.73 and Rs.1573 respectively, for last six months. This shows that coal mine workers are facing higher direct costs of gastrointestinal problems than non-coal workers.

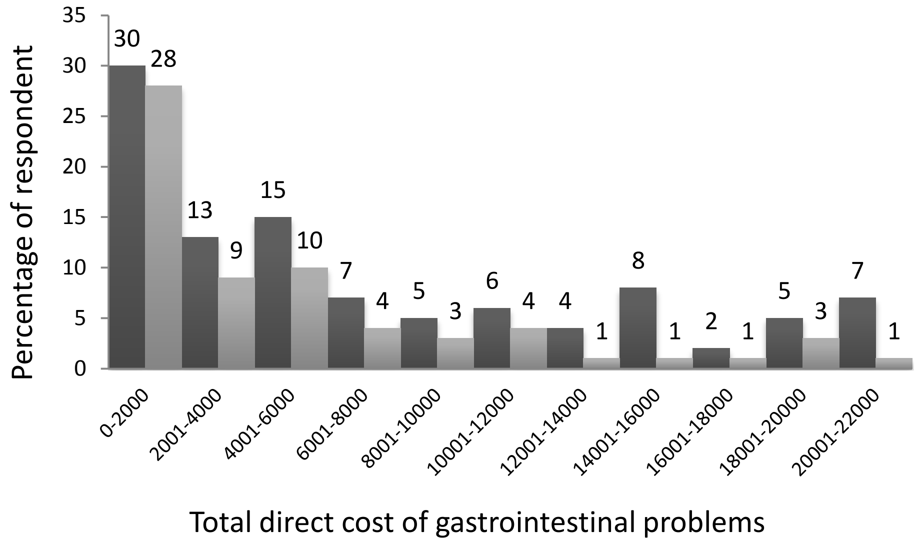

Figure 4.6 Comparison of total direct costs in percentage of coal mine and non-coal workers

Frequency distribution for musculoskeletal harms of coal mine workers and non-coal workers is shown in figure 4.7. The average frequency of musculoskeletal harms is 25.16 and 13.19 times respectively for coal mine and non-coal workers during last six months. From figure we can clearly observe from the first group where 20% and 49% of coal mine and non-coal workers are getting sickness non-coal between 0 to 10 times, respectively during last six months. In the 5th group of frequency distribution where 16% and 3% of coal mine and non-coal workers are getting sickness in the range of 31 to 40 times, respectively for last six months. We can see from left to right that the percentage of frequency distribution are decreasing for non-coal workers and increasing for coal mine workers implying that, coal mine workers are suffering more from musculoskeletal harms than non-coal workers.

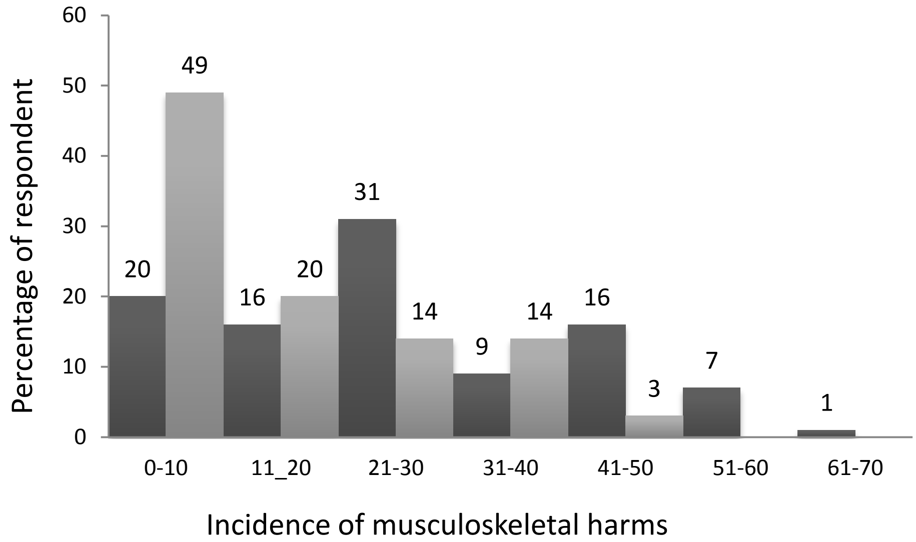

Figure 4.7 Frequency distribution of musculoskeletal harms of coal mine and non-coal workers

Direct costs of musculoskeletal harms of coal mine workers and non-coal workers is shown in figure 4.8. We can see from the first frequency group where 56% of coal mines workers and 82% of non-coal workers direct costs fall between 0 to 4000 rupees for last six months. In the same way group 6^{th} shows that 5% of coal mine workers and 0% of non-coal workers direct costs is between 20001 to 24000 rupees. The average direct costs of coal mine workers are 5823.53and 1999.46 rupees for non-coal workers. This means that coal mine workers are facing higher direct costs for musculoskeletal harms than non-coal workers have.

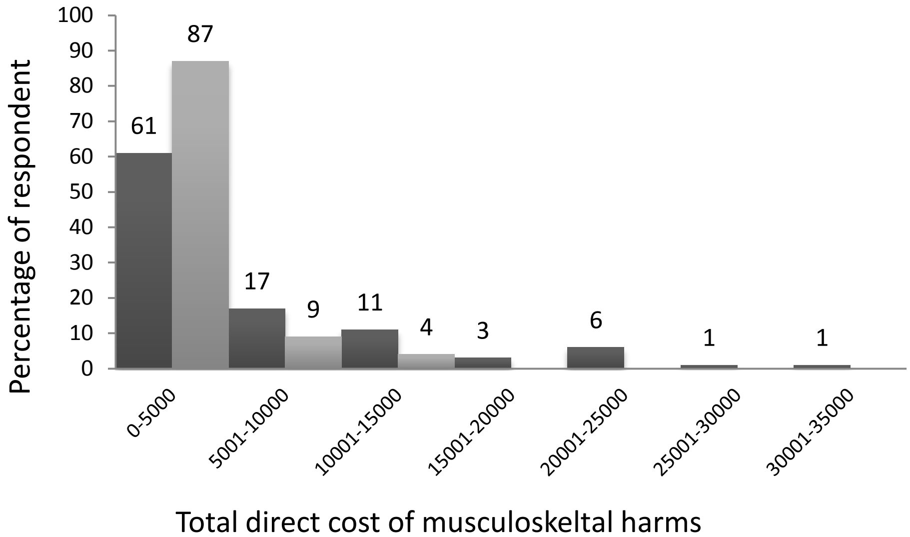

Figure 4.8 Comparison of total direct costs in percentage of coal mine and non-coal workers

The average frequency of headache for coal mine and non-coal workers is in the range of 16.4 and 5.74 times, respectively during last six months. From first group we can clearly observe that 20% and 45% of coal mine and non-coal workers frequency is in the range of 0 to 5 times, respectively during six months. In the second last group where 7% and 1% of coal mine and non-coal workers frequency is in the range of 46 to 50 times, respectively during six months. We can see from left to right that the percentage of frequency distribution are decreasing for non-coal workers and increasing for coal mine workers. This implies that coal mine workers are facing more sickness than non-coal workers.

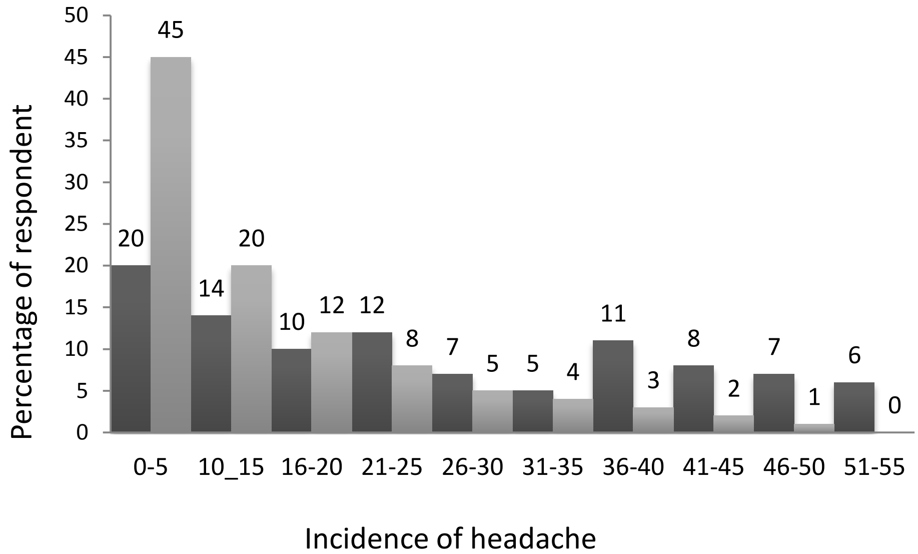

Figure 4.9 Frequency distribution of Headache of coal mine workers and non-coal workers

Direct costs for headache of coal mine and non-coal workers are shown in figure 4.10. We can clearly observe from figure where 43% and 65% of coal mine and non-coal workers direct costs of health is in the range of fall 0 to 1000 rupees, respectively for last six months. In the 3rd frequency group where 10% and 12% of coal mine and non-coal workers direct costs is between 2001 to 3000 rupees, respectively form last six months. The average direct costs of coal mine and non-coal workers are Rs.1651.26 and Rs.369.79 respectively for last six months. This implies that coal mine workers are facing higher direct costs of headache than non-coal workers.

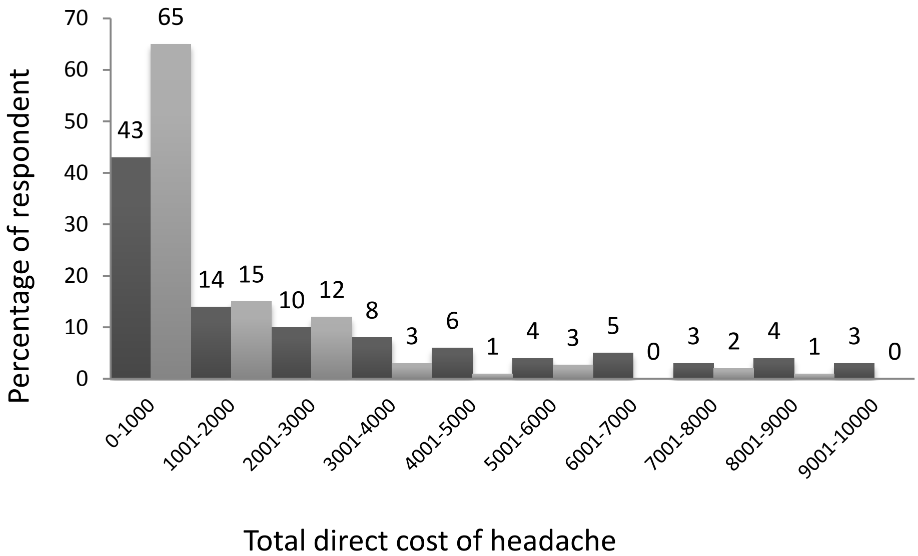

Figure 4.10 Comparison of total direct costs in percentage of coal mine and non-coal workers

Descriptive statistics of sample are reported in Table 4.1. Results for socio-economic variables indicate that there is significant differences in mean value of education, income, wage rate and working hours of coal mine and non-coal workers. However, there is no significant difference in mean value of age of coal mine and non-coal workers. While frequencies and direct costs of five different illnesses are positive and statistically significant at 1% level, respectively. There is significant difference in mean value of direct costs of coal mine and non-coal workers. Indirect costs occurred due to different illnesses is also positive and highly significant at 1% level, respectively. This implies that there is significant difference in mean value of total health costs of illnesses of coal mine and non-coal workers.

Table.4.1. Descriptive Statistics of Sample

Variables	Coal Mine Workers (N = 150)	Non-Coal Workers (N = 150)	
Socio-Economic Variables			
	Mean (SD)	**Mean (SD)**	**Difference**
Age of respondents (number of years)	29.03(7.15)	29.28(7.55)	0.24
Education level (number of years)	1.74(2.45)	3.08(3.73)	1.33***
Income of respondents (rupees per month)	21406.67(3437.06)	14320(3594.96)	7086.66***
Working hours (number of hours)	10.06(1.88)	8.68(0.89)	1.38**
Wage rate (rupees per day)	879.33(104.78)	525.06(144.60)	354.27***
Types of illnesses observed during last six months			
Frequency of respiratory illness	26.04(19.76)	7.56(11.72)	18.48***
Total costs of respiratory illness	4642.6(5051.87)	1267.13(2342.38)	3375.47***
Frequency of irritation of body	14.54(16.82)	4.14(8.34)	10.4***
Total costs of irritation of body	2146.93(3245.05)	447.66(1058.84)	1699.27***
Frequency of gastrointestinal problems	22.34(16.71)	7.74(9.90)	14.6***
Total costs of gastrointestinal problems	4948.06(5773.49)	1573.23(2693.44)	3374.83***
Frequency of musculoskeletal harms	25.16(17.22)	13.19(14.49)	11.97***
Total costs of musculoskeletal harms	5823.53(7008.43)	1999.46(3113.32)	3824.07***
Frequency of headache	16.4(14.08)	5.74(7.88)	10.66***
Total costs of headache	1651.26(2440.39)	367.33(596.80)	1283.93***
Total direct and indirect costs of illnesses for last six months			
Total Costs of Illnesses	36049.47(24768.83)	11932.27(11491.85)	24117.2***

***, ** Mean values are significantly different at 1% and 5% level, respectively.
Note: Mean values are shown with standard deviation in parenthesis.

4.2 Econometrics Analysis

In this section I will attempt to employ double hurdle model for each symptoms (respiratory illness, irritation of body, gastrointestinal problems, musculoskeletal harms and headache). In the first stage, the model is used to solve simultaneously workers decisions of getting treatment (either self or from doctor). It is binary decision whether to spend something on treatment or not. The second tier of the model shows the intensity of workers total direct costs of visiting doctors for better treatment. The decision of getting treatment and intensity of costs depends upon many influencing factors like economic, social, cultural, demographic and environmental related variables.

The marginal effects of double hurdle (DH) model for respiratory illness is reported in Table 4.1. The coefficients of profession in the first and second tier are positive and statistically significant at 5% and 10% level, respectively. Result for the first tier of DH model indicates that there is 164% points of probability of coal mine workers to get treatment either self or from doctor. The result of the second tier indicates that direct costs of respiratory illness increased by Rs.5513.05 for each marginal change of respiratory illness of coal mine workers. This implies that the probability of getting treatment and direct costs of respiratory illness are higher for coal mine workers than their counter parts (for non-coal workers).

Other variable that affect the decision of getting treatment positively are wage rate, working hours, frequency of respiratory illness and the coefficient of these variables are significant. However, living condition (sleeping place) is negative and significant at 1% level, implying that workers living in improved living conditions are visiting doctors 302 percentage points less than their counterparts. Living condition has also drastically large impact on workers' health cost and coefficient is significant at 1% level with negative sign. This implies that workers living in clean environment are spending Rs.3840.89 less than those who live medically unsafe environment. Hence, it is reasonable to argue that Government should invest or coal mine owners should be forced to invest to develop labor colonies away from working place which is appropriately safe for living. The variables age, education, and distance from medical treatment are not affecting workers decision to get treatment. However, age, education, living condition, and width of coal seam have negative and significant impact on direct cost of respiratory illness (Table 4.1). On the other hand frequency of illness, concentration of methane gas (CH_4) and working hours are contributing positively in direct cost. Our empirical results reveal that frequency of respiratory illness has positive and significant impact on direct health cost of coal mine workers. When frequency of illness increases by 1 times lead to increase health cost by Rs.148.72 within last six months. Concentration of poisonous gases like methane (CH_4) is found to have positive and significant impact on coal mine workers health cost. This natural and understandable that as concentration of poisonous gases will increase labor will get sick more. Hence, Government while developing coal mine policy should define the maximum level of poisonous gases within the permissible limits as specified by NIOSH. Our studies recorded 3.26% of CH_4 inside coal mines which is (3.21%) higher than the permissible exposure limit of NIOSH (0.05%). Width of coal mine seam has negative and significant impact on coal mine workers respiratory health cost. This implies that as width of coal mine seam increases cost of illness decrease and it is mainly due to decrease in density of poisonous gases and coal dust. Hence, Government while developing policy of coal mines should specifically mentioned the size of seam which could significantly lead to reduce health cost. The coefficient of working hours is highest than concentration level of methane gas and frequency of illness. This implies that beside methane gas there are some other environmental related factors (coal dust) which we did not take into account (measurement issues) but has been captured approximately through working hours is significantly contributing to increase direct cost of respiratory illness of coal mine workers. Hence, in order to relief coal mine workers a strict working policy as specified by ILO and given in The Mine Act 1923 of Pakistan not to allow to work more than 8 hours a day need to be strictly implemented. Our results also reveal that coal mine workers have higher direct cost of Rs.5513.05 than their counter parts (non-coal mine workers).

Table 4.2.Marginal effects for double-hurdle (DH) models

Variables	**First Tier** (Decision to get treatment)	**Second Tier** (Total direct costs of illness)
Age of the respondent	0.00	-65.50**
	(0.01)	(27.33)
Education level	0.05	-123.86*
	(0.04)	(73.49)
Income of the respondent	-0.00**	-1.01
	(0.00)	(1.62)
Profession (1=coal mine	1.64**	5513.05**
workers, otherwise 0)	(0.63)	(2667.31)
Living condition (dummy)	-3.02***	-3820.89***
	(0.55)	(901.51)
Working hours	0.01*	1992.93***
	(0.20)	(249.79)
Distance from medical treatment	-0.00	0.31
	(0.00)	(1.34)
Width of coal seam	-	-738.50**
		(319.44)
Length of coal mines	-	-0.01
		(0.34)
Concentration level of O_2	-	193.92
		(294.15)
Concentration level of CO	-	-100.86
		(74.39)
Concentration level of CH_4	-	828.15**
		(413.48)
Frequency of illness	0.08***	148.72***
	(0.01)	(18.63)

***, **, * significant at the 1%, 5% and 10% respectively and standard error in parentheses

The marginal effect for irritation of body is shown in Table 4.3. The coefficients of profession in the first and second tier are positive and statistically significant at 1% and 5% level. Result of the first tier of DH model indicates that there is 221% points of probability of coal mine workers to get treatment either self or from doctor. Result of the second tier indicates that direct costs of irritation of body increased by Rs.1248.04 for each marginal change of irritation of body of coal mine workers. This implies that the probability of getting treatment and direct costs of irritation of body are higher for coal mine than their counter parts. Other variables that affect the decision of getting treatment positively are education level and frequency of illness. However, age of the respondents, living condition, distance from medical treatment and nationality of the respondents (local residents=1 otherwise 0) are negative and statistically significant impacts on workers decision whether to get treatment or not.

The socio-economic variables like age of the respondents, educational level, and nationality of the respondents, living condition and structure of coal mines (width of coal seam) have negative and statistically significant impacts on health costs of coal mine worker. If government provides facilities of education, training and clean living environment both for local resident and non-local workers, the higher cost of illness of coal mine workers will be reduced. On the other hand working hours, frequency of illness and distance from medical treatment have positive and statistically significant impacts on costs of illness of coal mine workers. While income of the respondents, age when work started, nationality of the respondents, length and concentration level of methane gas (CH_4) are not affecting health costs of coal mine workers in case of irritation of body. Our empirical results reveal that numbers of working hours are contributing positively in direct cost. When working hour increases by 1 hour, lead to increase health costs by Rs.560.94 within last six months. Hence to reduce health costs of coal mine workers, strict rules and regulation should be implemented. Frequency of illness has also significant impact on workers' health cost. When frequency of illness increases by 1 time, lead to increase health cost by Rs.169.91 within last six months. Structure of coal mines like width of coal seam has also impacts on health cost of coal mine workers. This shows that as width of coal seam increases by 1 foot, costs of illness of coal mine workers decrease by Rs.191.21. Government and coal mine owner should specified the size of coal seam before extracting coal by coal mine workers. From the above discussion, it is concluded that coal mine workers are facing higher health costs than their counter parts.

Table 4.3.Marginal effects of double-hurdle models

Variables	**First Tier** (Decision to get treatment)	**Second Tier** (Total direct costs of illness)
Age of the respondent	-0.42**	-12.31*
	(0.22)	((13.19)
Education level	0.23*	-59.83*
	(0.10)	(50.82)
Income of the respondent	-0.00	-0.00
	(0.00)	(0.02)
Profession	2.21***	1248.04**
(coal worker=1, otherwise 0)	(1.13)	(465.81)
Living condition (dummy)	-1.44*	-35.28**
	(0.90)	(287.14)
Working hours	1.37	560.94***
	(1.05)	(160.29)
Distance from medical treatment	- 0.11*	2.35**
	(0.03)	(0.93)
Width of coal seam	-	-191.21**
		(66.29)
Length of coal mines	-	0.26
		(0.14)
Concentration level of CH_4	-	137.32
		(122.86)
Frequency of illness	0.20***	169.91***
	(0.03)	(14.31)
Nationality (dummy)	-1.39***	-3.96
	(0.52)	(172.40)
Age when work started	0.11	33.10
	(0.06)	(25.49)

***, **, * significant at the 1%, 5% and 10% respectively and standard error in parentheses

The marginal estimation of DH model for gastrointestinal problems of workers is shown in Table 4.4.The coefficients of profession in the first tier and second tier are positive and statistically significant at 10% and 5% level, respectively. Result of the first tier indicates that there is 57% points of probability of coal mine workers to get treatment either self or from doctor. The result of the second tier indicates that direct costs of coal increased by Rs.1974.70 for each marginal change of gastrointestinal problems of coal mine workers. This shows that the probability of getting treatment and direct costs of gastrointestinal problems are higher for coal mine worker than non-coal workers. Other variable that can affect the decision of getting treatment positively are age of the respondents, working hours and frequency of illness. However living condition, nationality of the respondents and sources of drinking water (1= safe sources, otherwise 0) are negative and statistically significant. While education level, income of the respondents and age when work started are not affecting the decision of coal mine workers to get treatment either self or from doctor.

The variables working hours, distance from medical treatment and frequency of illness have positive impacts on direct cost of gastrointestinal problems of coal mine workers. On the other hand age of the respondents, living condition, living condition; sources of drinking water and width of coal seam have negative and statistically significant impacts on direct cost of gastrointestinal problems of coal mine workers. While education level, income of the respondents, age when work started, nationality of the respondents, length of coal mines, concentration level of methane gas (CH_4) and threshold limits of oxygen (O_2) are not affecting direct costs of gastrointestinal problems.

Empirical results of the DH model for gastrointestinal problems shows that the coefficients of working hour are larger than living condition, frequency of illness and width of coal seam. Number of working hours is drastically contributing positively in direct costs. When working hour increases by 1 hour, lead to increase health costs by Rs.3084.95 within last six months. Sources of drinking water (safe sources=1, otherwise 0) are also affecting health costs of coal mine workers. When safe sources of drinking water increases, direct costs of health of coal mine workers decreases by Rs.834.30 within last six months. This shows that government and owner of coal mines should provide safe drinking water facilities (water filtration plants).

Table 4.4 Marginal effects of double-hurdle models

Variables	**First Tier** (Decision to get treatment)	**Second Tier** (Total direct costs)
Age of the respondent	0.32**	-14.29*
	(0.01)	(18.56)
Education level	0.03	58.97
	(0.03)	(50.32)
Income of the respondent	0.00	-0.03
	(0.00)	(0.04)
Profession	0.57*	1974.70**
(1=coal workers, otherwise o)	(0.33)	(846.51)
Living condition (dummy)	-2.61	-661.69*
	(347.62)	(575.44)
Working hours	1.04**	3084.95***
	(0.31)	(177.31)
Distance from medical treatment	-	6.534***
		(1.63)
Width of coal seam	-	-207.26*
		(177.62)
Length of coal mines	-	0.84
		(0.30)
Concentration level of CH_4	-	21.48
		(270.28)
Concentration level of O_2	-	-293.41
		(237.38)
Frequency of illness	0.33***	94.15***
	(0.07)	(25.73)
Sources of drinking water	-1.75***	-834.30*
(dummy)	(0,36)	(826.23)
Nationality (dummy)	-0.42*	-56.94
	(0.25)	(316.6)
Age when work started	0.01	-4.73
	(0.40)	(42.72)

***, **, * significant at the 1%, 5% and 10% respectively and standard error in parentheses

The marginal estimation of DH model for musculoskeletal harms is shown in Table 4.4. The coefficients of profession in the first and second tier of DH model are positive and statistically significant 1% and 5% level, respectively. Result of the for tier indicates that there is 215 % points of probability of coal mine workers to get treatment either self or from doctor. Result of the second tier shows that direct cost increased by Rs.438.91 for each marginal change of musculoskeletal harms of coal mine workers. This implies that the probability of getting treatment and direct costs of musculoskeletal harms are higher for coal mine workers than their counter parts. Other variables that can affect positively the decision of coal mine workers to get treatment are age of the respondents, working hours, and frequency of illness. The variables that cannot affect the decision of coal mine workers to get treatment are education level, income of the respondents, distance from medical treatment and nationality of the respondents.

The variables working hours, distance from medical treatment frequency of illness, and concentration level of carbon monoxide (CO) have positive and statically significant impacts on direct costs of coal mine workers in case of musculoskeletal harms. While those variable which have negative and statically significant impacts on health cost of coal mine workers are age of the respondents, living condition, nationality of the respondents, age when work started and width of coal seam. However, education level, income of the respondent, length of coal mines, concentration level of methane gas (CH_4) and threshold limits of oxygen (O_2) are not affecting health costs of coal mine workers in case of musculoskeletal harms. The coefficient of CO is highest than the working hours and frequency of illness. When concentration level of CO increases by 1 ppm (parts per million), the health costs of coal mine workers increases by Rs.1169.59. This indicates that higher concentration level of CO inside coal mines can increase health costs. So, check and balance of CO inside coal mines specified by safety agencies can play crucial role to reduce the health costs of coal mine workers. From the estimations and above discussion , it is concluded that coal mine workers are suffering more from musculoskeletal harms and facing higher direct cost of health than non-coal workers.

Table 4.5.Marginal effects of double-hurdles models

Variables	**First Tier** (Decision to get treatment)	**Second Tier** (Total direct costs)
Age of the respondent	0.08*	-49.13*
	(0.04)	(26.08)
Education level	-0.08	-83.70
	(0.17)	(81.74)
Income of the respondent	0.00	-0.08
	(0.00)	(0.07)
Profession	2.15***	438.91**
(1=coal workers, otherwise 0)	(2.26)	(216.34)
Living condition (dummy)	-	-467.97**
		(167.80)
Working hours	0.99**	536.88***
	(0.72)	(259.58)
Distance from medical treatment	0.02	5.67**
	(0.004)	(1.83)
Width of coal seam	-	-1328.79*
		(814.58)
Length of coal mines	-	0.39
		(0.49)
Concentration level of CO	-	1169.59**
		(596.62)
Concentration level of CH_4	-	783.97
		(504.15)
Concentration level of O_2	-	-380.52
		(394.43)
Frequency of illness	0.57**	80.96***
	(0.17)	(19.96)
Nationality (dummy)	-1.02	-646.38
	(0.75)	(468.66)
Age when work started	-0.04*	-23.04
	0.13	(12.06)

***, **, * significant at the 1%, 5% and 10% respectively and standard error in parentheses

The marginal estimation of DH model for headache is reported in Table 4.6. The coefficients of profession in the first and second tier are positive and statistically significant at

1% and 5% level, respectively. Results of the first tier of DH model indicates that there is 215% points of probability of coal mine workers to get treatment either self or from doctor. The results of second tier shows that direct costs by increased by Rs.438.91 for each marginal change of headache of coal mine workers. This implies that the probability of getting treatment and direct costs of headache are higher for coal mine workers than their counter parts. Other variables that can affect the decision of getting treatment are age of the respondents, age when work started, frequency of illness and working hours. However, educational level, income of the respondents, distance from medical treatment and nationality of respondents are not affecting the decision coal mine workers of getting treatment either self or from doctor.

The variables such as age when work started, width of coal seam have negative and significant impacts of cost of health of coal mine workers. However, working hours, frequency of illness, concentration level of carbon monoxide (CO) and concentration level of methane gas (CH_4) have positive and significant impacts on health costs of coal mines workers in case of headache. While age of the respondents, income of the respondents, living condition, distance from medical treatment, length of coal mines, nationality of the respondents and threshold limits of oxygen (O_2) are not affecting cost of illness of coal mine workers in case of headache.

Our empirical results reveals that working hours are contributing positively in direct cost. When working hours of coal mine workers increases by 1 hour, lead to increase health cost by Rs.1439.19 during last six months. Hence, in order to relief coal mine workers a strict working policy as specified by ILO and given in The Mine Act 1923 of Pakistan not to allow to work more than 8 hours a day need to be strictly implemented Results of the second tier of DH model for frequency of illness is also positive and statistically significant at 1% level. When frequency of illness increases by 1 times lead to increase direct costs by Rs.30.11 within last six months.

The coefficient of living condition is higher than the education level and nationality of the respondents. This implies that each improvement in living condition of coal mines workers can reduce costs by Rs.256.18 within last six months.

Concentration level of poisonous gases like methane gas (CH_4) and carbon monoxide (CO) are found to have positive and significant impact on coal mine workers health costs. However, detection of methane gas is very important to know about it concentration level in coal mining because higher concentration of methane reacts with air and displaces the prevalence of oxygen (Antao et al., 2005). On the other hand higher concentration of carbon monoxide inside coal mines is also hazardous for coal workers health because it enters to lungs and mixed with human blood. The movement of CO in blood vessels interferes with hemoglobin that carry oxygen (O_2) to tissues and hemoglobin combines with CO more readily than the oxygen. The movement of CO in blood vessels causes lack of oxygen as a result headache and suffocation occurred. This natural and understandable that as concentration of poisonous gases will increase labor will get sick more. Hence, Government while developing coal mine policy should define the maximum level of poisonous gases within the permissible limits as specified by safety agencies. From the estimation and above discussion it is concluded that the probability of getting treatment and direct costs of health in case of headache of coal mine workers are higher than the non-coal workers

Table 4.6 Marginal effects of double-hurdle models

Variables	**First Tier** (Decision to get treatment)	**Second Tier** (Total direct costs)
Age of the respondent	0.01	-1.80
	(0.00)	(9.72)
Education level	0.8**	-36.44*
	(0.02)	(30.04)
Income of the respondent	0.00	0.00
	(0.00)	(0.02)
Profession	0.81***	2211.91**
(1= coal workers, otherwise 0)	(0.22)	(1007.92)
Living condition (dummy)	-	-256.18
		(253.19)
Working hours	0.53***	1439.19***
	(0.11)	(116.40)
Distance from medical treatment	-	0.95
		(0.75)
Width of coal seam	-	-35.27*
		(44.17)
Length of coal mines	-	0.50
		(0.19)
Concentration level of CO	-	28.04*
		(21.67)
Concentration level of CH_4	-	183.23**
		(87.14)
Concentration level of O_2	-	31.97
		(110.88)
Frequency of illness	0.41***	30.11*
	(0.12)	(12.71)
Nationality (dummy)	-0.22	-106.20
	(0.16)	(187.81)
Age when work started	0.02	70.22**
	(0.01)	(25.72)

***, **, * significant at the 1%, 5% and 10% respectively and standard error in parentheses

4.3 Model Specification Tests

Model specification tests are reported in Table 4.7 which shows log-likelihood ratio tests that is used to test the suitability of the double-hurdle model against the most restrictive tobit specification. In the model, all five different diseases (respiratory illness, irritation of body, gastrointestinal problems, musculoskeletal harms and headache) of coal mine workers are tested. However, the result of the tests indicates that the null hypothesis in the favor of tobit regression model is rejected. Hence it is confirmed from LR test results that the double-hurdle specification is more appropriate for our data.

Table 4.7Model specification tests

Model Tests & Illnesses	Respiratory illness	Irritation of body	Gastrointestinal problems	Musculoskeletal harms	Headache
Log-likelihood of Tobit regression	-1510.08	-923.97	-1568.87	-1893.70	-1583.64
Log-likelihood of Probit regression	- 44.08	-28.37	-60.60	-11.39	-69.62
Log-likelihood of Truncated regression	-1432.22	-869.83	-1498.37	-1771	-1183.00
X^2 (16)	67.56	51.54	19.8	222.6	87.84
P-value	0.00	0.00	0.00	0.00	0.00

The descriptive statistics of coal mines are reported in Table 4.10 which shows types of coal mines based on width of coal seam, length of coal mines, concentration level of different gases such as carbon monoxide (CO), methane (CH_4) and threshold limits of oxygen (O_2). The average length of coal mines having 3 feet width seam has 1925 feet, while other types of coal mines having 5 feet and 9 feet width seam has 1990 feet and 2645 feet length, respectively. The concentration level poisonous gases (CO and CH4) in the study area are much higher than the specified limits of safety agencies. However, threshold limit of oxygen (O2) are close to the specified limits (18%) of safety agencies (NIOSH). The table indicates that width of coal mines has significant impacts of the concentration of poisonous gases. Our results of the study also reveal that width of coal seam has significant impacts on health cost of coal mine workers. Here, the table shows that concentration of CO and CH4 is higher in those coal mines which have small width of coal seam. Government and coal mine owner should specify the size of coal seam before extracting coal by coal mine workers.

Table 4.8 Descriptive statistics of coal mines

Types of coal mines	**Average Length of coal mines (feet)**	**CO concentration per coal mines (ppm)**	**CH_4 concentration per coal mines (%)**	**O_2 concentration per coal mines (%)**
Coal mines having 3 feet coal seam	1925	48.9	3.34	17.91
Coal mines having 5 feet coal seam	1990	41.3	2.3	18.52
Coal mines having 9 feet coal seam	2645	38.7	1.54	18.92

Chapter 5

Conclusion and Recommendations

This portion of the study is divided into two sections, i.e. Summary/conclusion of the study and policy recommendation on the basis of research work.

5.1 Conclusion

The earth has many natural resources and coal is also one of the major resources of the earth. Every nation depends on these natural resources. To fulfill the energy requirement of the nations, these natural resources are extracted at the high cost of human health and environment. Coal mining provides employment to a large number of labours and they are also considered as the most important factors of coal extraction but unfortunately health risk of these workers is not properly taken care. Coal mining is considered as one of the dangerous occupation globally and possesses many health problems to coal miners due to production and dispersion of coal dust. Putting labour in the forefront of development is a positive sign of social change but their health safety is also important not only for ethical reasons but also to exploit their maximum potential. Descending into dark, airless tunnels, coal mines workers extract coal with simple tools without adopting any protective measures, in addition to this no special training has being imparted to workers before sending them into underground coal mines. Hence, Inhalation in the presence of poisonous gases (CH_4, CO_2, CO, and O_2 below threshold limit), explosions and coal mines dust are responsible to cause several types of diseases. God has gifted Pakistan with immense natural resources. According to the literature review given we observed that none of the study investigated the relationship between environmental pollution and health costs. There are many studies done to explore aspect of coal mining in different parts of the world. It is not sufficient to study the impacts of environmental pollution on health damages which does not indicates the monetary value of health damages of coal mine workers. According to best of our knowledge no study has investigated such relation earlier. Hence, present study is unique in its perspective because it will estimate the health costs of illness and will also investigate the determinants of total health costs of coal mine workers in district Duki, Balochistan

The current study is investing the health impacts of coal mine workers due to working in polluting environment of coal mines. The study is exploring three dimensions like environmental pollution, illness and costs of the illness for two groups i.e. treatment (coal mine workers) and control group (non-coal workers). Environmental polluting variables are poisonous gases (CH_4 and CO) that affects coal mine workers' health. The concentration level of CH_4, CO and threshold limits of O_2 has been estimated inside mines at the working place of coal mine workers and for non-coal workers by using multi gas detector. Five different symptoms that lead to multiple diseases and commonly observed among treatment group are considered and compared for the two groups. Among these includes, respiratory illness, irritation of body, gastrointestinal problems, musculoskeletal harms and headache. The costs of illness consist of two components, i.e. direct costs and indirect costs. Direct costs includes, travel costs, food costs, treatment costs, costs due to hospitalization, expenditures on medicine and doctor fees, accommodation costs during visits to hospital and some other informal payments. Indirect cost consists of opportunity cost of complete and partial off days.

The primary data which is collected through well design and pre-tested questionnaires from 300 respondents is employed in this study. Sample is divided into two groups known as treatment group "coal mine workers" (s=150) and control group "non-coal workers" (s=150). There are different sizes of coal mines in the study area and therefore, I selected 30 coal mines of different sizes, length and width of coal seam at District Duki, Balochistan. Primary data is collected and analyzed by using DH model through STATA software. Two different tier of DH model are estimated and analyzed. The first tier is binary decision whether to get treatment or not and the second tier is total direct costs of workers health. For each illness a separate econometrics model is developed and results derived.

The frequency of sickness for each illness, probability of getting treatment either self or from a doctor and cost of illness for two groups is estimated and compared. The average value confirmed that coal mine workers are suffered more from different diseases. They are facing higher probability of sickness and thus also getting treatment more frequently. This leads to higher costs of health (either direct costs or indirect costs) than non-coal workers. It is observed that many socio-economic and demographic factors are responsible for higher frequency and costs of illness for coal mine workers. Among these socioeconomic variables are age of the worker, educational level, experience, wage rate and income of the respondent, distance from medical treatment, living condition, sources of drinking water and nationality of the workers. The environmental related variable like poisonous gases (CH_4 and CO) and their concentration level is also measured and compared for the two groups. The structure of coal mine such as length of coal mines and width of coal seam is also affecting frequency of illness and thus costs of illness.

In this study I have attempted to employ double hurdle model for each symptoms (respiratory illness, irritation of body, gastrointestinal problems, musculoskeletal harms and headache). The marginal effects of double hurdle (DH) model are reported for all five diseases of coal mine workers. The coefficient of profession (coal workers =1, otherwise 0) is positive and statistically significant for all diseases. The result indicates that direct costs of respiratory illness increased by Rs.2290.32 for each marginal change of respiratory illness within last six months. Direct costs of irritation of body and gastrointestinal problems of coal mine workers increased by Rs.1248.04 and Rs.1974.70 for each marginal change of both diseases. While direct costs of musculoskeletal harms and headache increased by Rs.538.9 and Rs.2211.91, respectively for each marginal change of both diseases. This implies that the probability of getting treatment and direct costs of are higher for coal mine workers than their counter parts (for non-coal workers).

Those socio-economic, demographic and environmental factors/variables which are positive and statistically significant impacts on direct costs of coal mine workers health are frequency of illness, distance from medical treatment, age when work stared, concentration level of methane (CH_4) and carbon monoxide (CO). However, those factors/variables which are negative and having significant impacts on cost of illnesses of coal mine workers are included age of the respondents, education level, nationality of the respondents, age when work started, living condition, sources of drinking water and width of coal seam. Hence in the DH model, age when work started is the only factor which has combine affects (negative and positive) on direct costs of illness of coal mine workers. The overall conclusion of the above discussion is that coal mine workers are facing higher frequency and costs of illnesses as compared to non-coal workers.

5.2 Policy Recommendations

In order to reduce the frequency of illness and costs of workers' health, following policy are recommended to improve the potentiality and productivity of coal mine workers.

- Our empirical findings reveal that poisonous gases (CH_4 and CO) have significant impacts on health cost of coal mine workers. So, an effective safety program with provision of all safety tools and techniques should be provided. Awareness should be created about health hazards like poisonous gases and provide them guidance to reduce the health risk related to coal mining through joint coordination of government and safety agencies (NGOs).

- Government should play its effective role by monitoring and forcing the private sector to improve the condition of coal mine workers (local and foreign workers) and must provide clean and protected houses, filtration plants for safe drinking water which will increase labour potentiality and productivity.

- Our empirical result reveals that width of coal seam has significant impacts on direct costs of coal mine workers health. So, Professional mines engineers and managers with advance tools and techniques should be hired to remove the outdated and local system of mining and restructure the shape of coal mines to overcome the problem of poisonous gases, threshold limits of oxygen.

- It is also observed mostly coal mine workers are uneducated and away from getting treatment (hospitals). Government should provide them education and health facilities to overcome the issues of higher costs of illness.

- It is also observed that in few cases even coal mine owners have provided safety tools to workers but they are not using it. Moreover, carelessness of workers like eating, drinking and smoking inside coal mines are often observed among coal mine workers. This implies awareness among workers about the importance of safety tools and to adopt protective measures to avoid risk need to develop among workers.

3 Future Research

Due to budget and time constraints present study is conducted on verbal responses of the respondents. Future research can be done through medical test of illness of coal mine workers.

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Questionnaire

Environmental Pollution and Health Costs Faced by Miners Working in Underground Coal Mines: Evidence from District Duki, Balochistan

This questionnaire is designed to collect data from coal mine workers having occupational illness. The questionnaire will further study the health problems, costs of illness and determinant of total costs of coal mine workers in District Duki, Balochistan.

Date --------/---------/2018 Sample no. -----------

Name of household head…………………. ……

Name of respondent…………………………….

Years of Education……………………………..

Age………………………………….. ………

Age when work started………………………….

Marital status….. (Single/Married/Divorced)

Since how long you are working in coal mining...

Nationality of the respondent…………………….

Name of District………………………………….

Current residence distance from coal mines……..

Average monthly income …………………………

Household size…………………………………….

Basic information from coal mines worker's (Questions and Answers)

Q1. Do you work in coal mining?	Yes	No

If yes,

Working hours……………………

Working days per week……………

Wage per day RS………………….

Permanent Income RS………………

Income from other sources………….

Q2. How long the length of coal mine is?

Q3. How much width the coal mine seam has?	a. 3 feet	b. 5 feet	c. 9 feet

Level of concentration of three major gases of coal mine?

Name of Gases	Level of concentration
a. **Methane (CH_4)**, (unit = %)	
b. **Carbon monoxide (CO)**, (unit=ppm)	
c. **Oxygen (O_2)**, (unit= %)	

Q4. Is your company using the equipment to identify the level of poisonous gases and measurement of dust concentration before going to underground for coal extraction?	Yes	No

Q5. Do you use any safety tools and devices such as masks, safety clothes, gloves, helmet during coal extraction?	Yes	No

Q6. If the answer of above question is yes, then what is the quality of protective measures?

a. Very good	b. Good	c. Poor	d. Very poor

Q7. Who are providing you safety tools and devices for underground coal mining?

a. Government	b. NGOs	c. Owner of the coal mine	d. Self-purchasing

Q8. Any accident occurred within last 6 months in coal mining? Yes No

If yes, then which type of accident occurred?

a. Gases explosion	b. Collapse of rope & stops	c. Flooding	d. Others

Q9.Due to accident, anyone injured or anybody death occurred?	Yes	No

Q10. In last six months did you faced any of the following health problems?			**Frequency**
a. Respiratory illness	Yes	No	
b. Irritation of body			
c. Gastrointestinal problems			
d. Musculoskeletal harms			
e. Headache			

Q11. Do you currently have any of the above illness?	Yes	No
Q12. Do you think the above illness among coal mine workers is due to working in coal mining?	Yes	No

Q13.Do you have any family history for any disease mentioned above?	Yes	No

Q14. Mostly where you got health treatment?

a. Government hospital	b. Private health care center	c. Coal company provided health care center

Q15. If the problem is serious then where you go for better treatment and what is the distance of treatment facilities?

Illness	Govt.	Private	Company	Distance
Respiratory illness				
Irritation of body				
Gastrointestinal problems				
Musculoskeletal harms				
Headache				

Q16. Does the company compensate you for health?	Yes	No

a. If yes, then
   1. Full compensation…………………
   2. If not fully, then please mention amount of compensation Rs…………………..

Q17. Who supply food for you while working in coal mines?

a. Household	b. Locally purchased	c. Coal mine cooker

If food is cooked by coal mine cooker, then

Q18. What is the quality of food and cooking environment?

a. Very good	b. Good	c. Poor	d. Very poor

Q19. What are the sources of drinking water?

a. Filter water	b. Nestle water	c. Pond water	d. Nearby tube well

If the sources of drinking water are pond water and nearby tube well, then

Q20. What is the quality of water for drinking?

a. Low	b. Medium	c. High

Q21. Direct and indirect costs on each disease within last 6 months are?

Diseases & its cost	Respiratory illness	Irritation of body	Gastrointestinal Problem	Musculoskeletal harms	Headache
Frequency of illness					
Diagnostic test cost &					
its frequency					
Doctor fee &					
no. of visit					
Cost of hospitalization, accommodation &					
its frequency					
Cost of medicine					
Food cost					
Travel cost					
Other cost like protective measures etc.					
Total cost					
Work days off					
Partial off days					

Q22. If you got disabled due to illness or die, is there any social protection programme from owner for your family?	Yes	No
Q23. Is any trained medical person available all a time in working hour of coal mine workers for your emergency?	Yes	No
Q24. If the answer of the above question is yes, is the medical person has equipped with emergency tools/equipment?	Yes	No

Q25. Are there any government rules, standards and regulation to protect the health of coal mine workers?	Yes	No

Q26.Are government official's visits to reinforce coal mining standards, rules and regulations?	Yes	No

If the answer of above question is yes, then

What is the level of official's visits for management, supervision and regulating the standards and rules of coal mining?

a. Very good	b. Good	c. Poor	d. Very poor

Q27. Are there any awareness programs about hazardous effects of coal mining by government, coal company or NGOs?	**Yes**	**No**

Q28.Are you satisfy from government provided medical facilities and supervision of mining through rules, standards and regulations?

a. Strongly Satisfy	b. Satisfied	c. Unsatisfied

Q29. Are you aware of the following rules & regulations for mine workers?	Yes	No

Rules for Mine Workers (The Mines Act, 1923)		ILO Standards for Mines Workers	Existing situation in Duki
1	Sixteen days sick leave on half average wages.	Same	
2	Ten days casual leave on full wages in a year		
3	Full wage during public holidays declared by Government	Same	
4	6 days or 40 hour per week	Same	
5	Availability of first aid rooms and medical appliances	Same	
6	Mine latrine, supply of water fit for drinking, cooking and other purposes		
7	Standards of such shelter and canteens facility		
8	Registration of every worker by name, date of birth ,nature of employment & uses of protective measures	Same	
9	Notices of occupational diseases to the concerned department	Same	
10	No child should be employed in mine	Same	

If yes,

Q30. Do you think the above rules & regulations are followed? Yes No

If no, what are the reasons?

1. …………………………………………………………………………………………
2. …………………………………………………………………………………………
3. …………………………………………………………………………………………

Q31. Are you satisfied with current health services?	Yes	No

If no, what should be done?

1. ………………………………………………………………………………………
2. ………………………………………………………………………………………
3. ………………………………………………………………………………………

Q32. Can workers form a group and contribute money to meet emergency health expenditure of ill coal workers?	Yes	No

If yes, how much you will be willing to pay to contributes?

1. Rupees PK……………………………………………………………………………

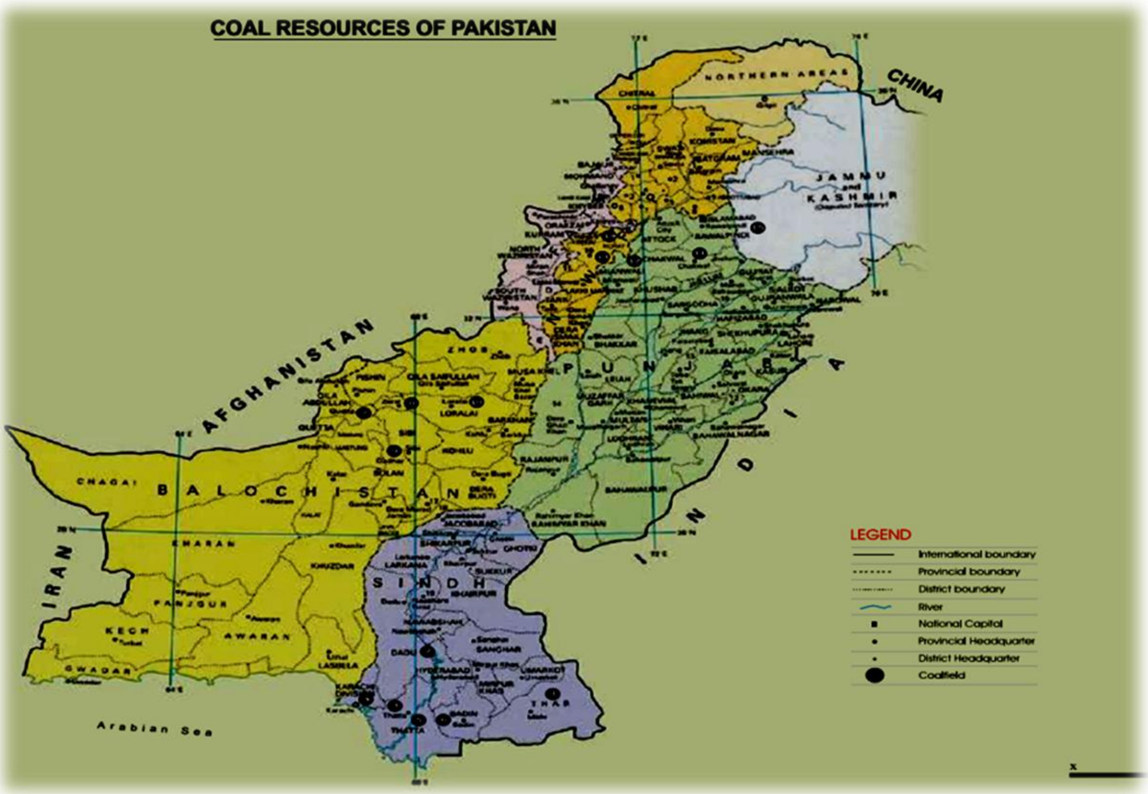
If no, why and what are the reasons?

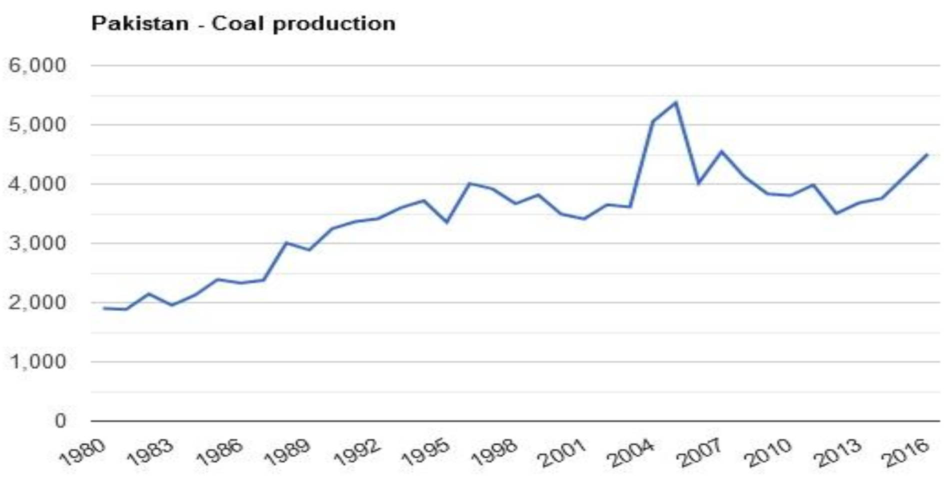
1. ………………………………………………………………………………………
2. ………………………………………………………………………………………
3. ………………………………………………………………………………………

Q33. Are you feeling difficulty of inhalation and exhalation (breathing) during work in coal mine?	Yes	No

Employee signature: ………………. Dated: ……………… Thanks for your cooperation.

Appendix:





Source: TheGlobalEconomy.com, The U.S. Energy Information Administration

District Duki, Coal Mines by Google Map

Coal Miners Working Condition

A District Duki, Coal Mine Workers are ready to go Underground Coal Mine without Using protective measures i.e. proper dress, gloves, protective shoes and halmet etc.








Kitchen
Sleeping place
Coal Mine

10:28
کراچی: ہجرت کالونی میں پولیس کا سرچ آپریشن، 7 غیر ملکی گرفتار


Estimating level of Poisonous Gases in Underground Coal Mines by Multi Gas Detector

Condition of District Duki, Coal Mines Rescue Station (2017)