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Welfare Impact of Dust Pollution on Human Health in the District Khyber Ex-FATA, Pakistan

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ABSTRACT

Dust pollution is among the major cause of disease and death all around the world. The lungs and respiratory system are the primary targets of ambient dust pollution. This study aims to estimate the health cost due to dust pollution from a stone crushing industry in the Khyber district of ex-fata, Pakistan. To examine the impact of dust pollution on respiratory illness, primary data was collected from 1278 individuals from 200 households living within a 3 km radius of the stone crushing industry. The Household Production Function and Mitigation Cost Function were used to determine the reduced-form equations for assessing the impact of dust pollution on human health and then estimating the monetary cost related to mitigating such diseases. The PM10 level in the crushing region was extremely high, averaging 1247g/m3, while the PM10 level in the control group was relatively low, at 45g/m3. According to our study, the regression analysis estimated that by reducing PM10 to a safe level, every individual could save PKR 4958 per year through mitigation costs. The Total welfare gain for district Khyber will be PKR 2453.306 million or (PKR 2.45 billion). Aside from that, individual productivity loss is estimated to be .37 per day per year. The monetary value of avoiding the restricted working day is PKR 23 for one home, whereas the monetary benefit of lowering the PM10 level is PKR 161000/ for

Keywords

Cost of illness, Dust Pollution, Health Cost, Workday Loss, Welfare analysis, Respiratory illness, Khyber

JEL Classification

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the entire district. The research study suggests implementing the ban on stone crush production and technology adaptation in the residential areas.

1. Introduction

Dust pollution is made up of tiny bits of dry solid material. It starts out as airborne particles and gradually settles on flat surfaces. Environmental, domestic, and industrial dust are the three main types of dust that can be produced anywhere. At home, we perform thorough cleaning without using excessive chemicals which are advised to remove the majority of the dust that is visible. The clinical literature is well versed in the devastating health impacts of dust pollution. High levels of ambient dust pollution have been linked to illnesses such as headaches, cancer, high blood pressure, asthma, heart disease, shortness of breath, etc (Mao, Peng, et al., 2017).

Industrial illnesses and injuries are associated with significant social and financial costs. This externality costs the individual a significant amount of money in terms of lost productivity and health costs. Furthermore, it takes a firm stand on a public bursary in terms of greater government spending. In many areas, dust pollution exceeds the National Air Quality Standard. The AQI is between 100 and 150. The short-term national ambient air quality standard for the protection of public health is typically equivalent to an ambient air concentration of 100 for each pollutant. In general, AQI levels of 100 or less are considered to be good. In the Pakistan air quality index, the World Health Organization (WHO) listed Pakistan as one of the top 10 most polluted countries on the earth (Muhammad Khan, 2017).

The environmental hazards are caused by industrial activity including dust pollution, water pollution, and soil contamination. Workers in the industrial sector; particularly in underdeveloped countries have always had to contend with filthy conditions and are regularly exposed to dust and particulate matter. The Small-scale stone crushers and unorganized sectors have existed in the Ex-FATA residential regions. These crushers are necessary for the construction of buildings and roads. They are involved in things that require a lot of time and effort. It supplies not just raw materials for buildings, bridges, and road construction, but also a source of income for the local people.

In Pakistan, industrial sectors badly pollute the environment containing water contamination, soil pollution, and air pollution. The Stone crushing workers have always had to contend with dirty conditions that are frequently devoid of particulate matter and dust, particularly in underdeveloped countries. Furthermore, stone crushing plants are one of

Pakistan's most important industrial sectors. In many hilly places, stone crushers have small-scale and unstructured sectors, yet these crushers provide the essential material for building and road construction. It not only provides a source of income for a small number of people, but it also provides raw materials for the construction of roads, buildings, and bridges, among other things. Stone crushers are involved in labor-intensive operations (Ilyas and Rasheed 2010).

Air pollution such as ozone and particle matter is known to contribute to human mortality and morbidity. However, humans could inhale particulate matter (PM) with a fine size of fewer than 10 micrograms known as PM10, which subsequently travels to the respiratory system and causes major health consequences. On the other hand, household sickness and health difficulties entail social and economic implications. While, Medication, travel, fees paid in treating diseases, and productivity loss are all examples of these costs.

The process contains drilling, raw material transportation; screening, rock blasting, crushing, material handling, size classification, storage activities, and final product transportation are all part of the stone crushing plants. In other words, significant amounts of suspended particulate matter (SPM) are emitted into the air because of mining operations. These particulates are dependent on particle weight, shape, and size since they are released from crushing machines and persist in the atmosphere for a long time, posing a risk to humans and plants alike (Prajapati &Tripathi, 2008).

The stone crushing sector produces high levels of dust exposing men and women in the community to a variety of occupational health risks. Hence, the severity of these disorders may have a significant impact on people's productivity, living standards, health, and life value. Due to inhaling dust on a regular basis, rural laborers notably those working in the stone-crushing business and especially inhabitants are suffering from a variety of illnesses such as Asthma, chest pain, shortness of breath, and allergies, as well as throat and skin infections. Because of their illiteracy, these workers' health deteriorates, and they are not aware of the importance of using safety equipment such as a facemask, and a cloth, among other things (Asante, Abass, (2014).

The purpose of this research was to determine the influence of dust pollution on human health in Khyber that has a negative impact on the environment and those who live or work near the crushing region. However, the objective of the study is to examine the Mitigation Cost (MC) and Workday Loss (WDL) of rural households in the Shakas area of district Khyber who are affected by the stone crushing industry.

2. Literature Review

The stone crushing industry is a central supplier of construction materials for the country's structures, canals, roads, etc. Stone crushing is an important industrial sector in Pakistan; where people work to produce various stones crushed and used as raw materials. In Addition, stone crushing plants are the key units that could be found in the residential areas of large cities, towns, states, and even the entire country. In other words, construction operations are ongoing throughout Pakistan for the benefit of society and economic progress. At the same time, it has increased the amount of dust pollution in the area which has a negative impact on occupational human health, air quality, and productivity.

The results of recent medical studies on the health effects of dust pollution are astonishing. To begin with, there are no "safe" amounts of dust pollution. Dust pollution affects practically every organ in the human body including the respiratory system which causes asthma and chronic obstructive pulmonary disease, as well as the heart, strokes, and even cancer. As a public health opinion, we are concerned that young children are particularly vulnerable to air pollution; new evidence suggests that air pollution exposure has a negative influence on children's cognitive development. Moreover, dust pollution is still a serious public health issue around the world. According to WHO estimates, 92 percent of the world's population is exposed to hazardous levels of air pollution (Adil Zareef & Muhammad Rafiq, 2021).

Dust pollution has a negative impact on human health by generating or worsening respiratory, cardiovascular, and visual disorders, as well as influencing allergic reactions. It also has an indirect effect on mortality in the region by reducing vision and causing travel problems due to the creation of fog and smog. Fog is formed when water droplets are suspended in the air at ground level. This is frequently associated with low-level air cooling and the formation of condensate, which can persist in steady conditions (e.g., low wind speeds and atmospheric inversions). These water droplets can increase the potential for fog formation in the presence of particle matter (both primary and secondary particles) by enhancing condensation nuclei and chemically interacting with fog droplets (Fatima & Zulifiqar, 2021).

Dust pollution is the leading cause of health problems all around the world but developing economies are particularly vulnerable. Dust pollution is made up of a complicated mixture of gaseous and particle components, all of which have negative effects on the cardiovascular and respiratory systems. Individuals in low- and middle-income countries (LMICs) have distinct exposures to respiratory diseases, and thus different risk factors, than those in higher-income nations. Infant lung function is harmed by increased prenatal household air pollution associated with exposure. Every year, more than 4 million people die because of diseases caused by pollution (Ubaid & Ayat, 2021).

Environmental degradation is a major issue in economics that has gotten a lot of attention from economists and environmentalists alike. Due to the tremendous growth of Carbon Dioxide (CO2) emissions, the world now faces the severe challenge of global warming. Pakistan has seen strong real GDP growth in recent years as well as a significant reduction in poverty. However, the continuous availability of important ecological services and natural resources is critical to human well-being. Pakistan's natural resources and ecosystem are becoming increasingly polluted and stressed. The country's most pressing environmental concerns are around the management of scarce natural resources greenhouse issues, pollution and waste management, brown issues, and possible vulnerabilities to natural disasters and climate change (Khan, I., & Hou, F. (2021).

Pakistan's ecology has suffered for many years due to poor natural resource management and very high population growth. Hence, agricultural and industrial runoff have fouled water supplies, manufacturing, and car emissions have impaired air quality in metropolitan areas, both of which are caused by continuous deforestation. Pakistan like other developing countries has prioritized achieving food self-sufficiency, fulfilling energy demands, and limiting its high rate of population increase over reducing pollution and other environmental hazards. As a result, "green" concerns have not been a key priority for the administration (EPA, 2021).

Due to the life-threatening consequences of dust pollution around the world; particularly in developing countries like Pakistan, groundbreaking research, massive positive input, widespread awareness, and pollution-reduction measures are all necessary. There are different environmental boosting activities from various environmental protection agencies and government or non-governmental organizations available in Pakistan's larger cities. Furthermore, smaller cities, towns, villages, and some divisions or districts, on the other hand, do not receive the same level of attention. However, Malakand Division is one of Pakistan's divisions that receives insufficient attention. From a new developmental perspective, the consequences are even more dangerous. (Ullah & Li, 2019).

Pakistan faces water pollution, soil erosion, land pollution, water scarcity, global warming, air pollution, and natural disasters are only some of the climatic and environmental concerns. Pakistan is on the list of countries with poor air quality, according to the latest global environment performance index (EPI) ranking. Furthermore, Climate change and global warming are the most concerning issues, threatening the lives of millions of people around the country. Carbon emissions, population growth, and deforestation are the primary causes of these environmental problems ((Andam, F., & Shi, 2017).

The epidemiology literature has recently discovered the harmful health impacts of dust pollution and air pollution. Although, high amounts of pollution were present which has been linked to a variety of morbidities including headaches, asthma, high blood pressure, cancer, bronchitis, and more. This externality resulted in a significant monetary loss to workers or persons in the form of decreased productivity and increased health costs (Rafiq & Munir 2014).

The stone crushing units are one of Pakistan's most important socio-economic sectors. They increase the amount of dust-related emissions and may cause a variety of health problems for the workers as well as the surrounding community. While trees developed in the area and numerous morphological characteristics were identified. The study looked into the influence of stone or marble dust on plants. The findings revealed that particulate matter (PM) of rather a significant size was created during the stone-crushing unit. Plant growth is severely harmed if particle matter is deposited on vegetative stems (Yashoda Saini, et al, 2011).

The KP Environmental Protection Act, 2014:

The KP Environmental Protection Agency is in charge of enforcing environmental laws in the region. The Environmental Protection Act of 2014, which was passed on December 11, 2014, outlines these regulations. It has rules and regulations in place to prevent dust, air pollution, and noise pollution. Nonetheless, section 11, section 13, and section 12 all deal with dust pollution. Section 17 specifies the penalties and fines that will be imposed on violators.

Section 11, EPA act, 2014:

"No individual shall omit, release, or authorize the emissions, discharge, or misuse of any sewage, misuse, Dust pollution, or Atmosphere pollution in quantities, attention, or levels that exceed the countrywide ecological value standard."

Section 13, EPA act, 2014:

"According to the KP Protection Act of 2014, no one may trade imperious substances whose chemical or physical motion is hazardous, radioactive, flammable, explosive, or creates a bad ecological effect whether used alone or in combination with other chemicals."

Section 14, EPA act, 2014:

"Anywhere the provincial and federal governments are pleased that the emission and discharge of any sewage water, dust, or atmosphere pollution, or the dumping of devastating, or the treatment of hazardous materials, or any extra substance and waste are possible or happening, or has accrued in violation of the act is possible or happening."

Section 17, EPA act, 2014:

The punishment and penalties imposed on offenders of sections 11, 13, and 14 of the Protection Act 2014 are discussed in this section. "Such penalties under section 17 will be punishable by a minor fee of 50,000 which may be increased to 50,0000 and in the case of persistent flouting of collapse, an additional fine of 10,000 for each day that such failure and contravention continue."

"The maximum penalty under section 17 is 50,0000 with a daily penalty of 100,000 if the infraction continues. This applies to any infraction under section 14 of the Environmental Protection Act of 2014 that is related to the conduct."

According to the crush production owner, they are not subject to any government taxes. Owners enjoy complete flexibility for not enforcing any laws or rules, there is no governance system in place, there is no political pressure, and many more factors are imposing a significant external cost on society. As far as welfare analysis is concerned, this ongoing study is an attempt to put a value on health costs for the population of Shakas in district Khyber.

3. Methodology

3.1 Theoretical Framework

The health production function was used to achieve the goals of our research. The health production function is a subset of the Household Production Function (HPF). The hypothesis leads to a necessity for the mitigation cost function (MC) and the workday loss function (WDL). Demand for mitigation cost function and health production function is implicit in the utility function to assess the health benefit of reduced dust pollution. A similar theoretical lens has been employed by Rafiq & Munir (2014), Usha (2006), and Naveen (2012).

We will now discuss the utility function in order to obtain the Mitigation Cost function and the health production function (Freeman, 1993). The following is the utility function:

$$U=U(Q, H, L, X) \quad \ldots\ldots (1)$$

In this equation, Q denotes dust pollution exposure, H means the number of workdays lost owing to pollution, L denotes an individual's free time, and X denotes the total consumption of commodities accessible on the market. Q & H provide the most dissatisfaction, whilst L & X provide the most satisfaction.

By combining mitigating efforts with a specified degree of dust pollution defined by Q, a person could improve their health. They also favor socio-economic uniqueness and another good health status. The following is how the household health production function is calculated:

H=H (Z, M, Q) ……. (2)

Z signifies a vector of health characteristics such as age, sex, and income in the given equation. Where M denotes Mitigation Cost (MC) and Q denotes the degree of dust pollution. H also counts the number of workday losses (WDL).

The preceding equation implies that an individual can maintain his health status in a polluted or dusty environment by paying a Mitigation Cost (MC). Now we will go over the individual budget constraint, which looks like this:

I= W+Y(H-T-L) = X + PaA+ PmM…. (3)

W is the wage rate, Y is non-wage earnings, and (H-T-L) is the total time spent at work, according to the above equation. The T stands for total time, and Pa and Pm are the prices for mitigation costs and lost workdays, respectively.

In the following equations, Q signifies the degree of dust pollution, I means the individual's income, W denotes the wage rate, and Pm reflects the price of mitigating actions and other explanatory variables. By simplifying the following problem, an individual could exploit revenue subject to (L, A, M, X) budget limitations.

MaxG= U (Q, H, L, X)+ ƛ(W+Y(H-T-L)-X-Pm-Pa)….(4)

The ƛ Lagrange function is shown in the above model. We acquire marginal willingness to pay (MWTP), health production function (HPF), workday loss (WDL) function, and further demand function for Mitigation Costs as a result of the foregoing models (MC).

A=A (H, Q, Z, Pm, Pa, W, X)…..(5)
M=M (H, Q, Z, Pm ,Pa ,W, X)…(6)
MWTP= W. dh/dq +Pm dm/dq+Pa dm/dq+ (ƛ/UH). Dq/dh ….. (7).

In equation 7, the total of visible reductions in Mitigation Cost, further explain disutility of sickness, monetary benefit, and Cost of disease is connected with marginal willingness to pay which gains health advantages by lowering dust pollution. The estimation of the (MWTP) also necessitates the estimation of the (HPF) and the Mitigation Cost Function.

The monetary gain from reducing dust pollution was captured in the first three equations above. The cost of illness (COI) is an important way to examine lower boundary estimates because avoiding expenditures is the most difficult to estimate effectively.

COI= W. dq/dh+ Pm dq/dm ……. (8)

In equation 8, the health benefit from reduced dust pollution is represented by the mitigation cost and workday loss.

3.2 Econometric Models and Specifications

The nature of the data is always influenced by the model's estimation. We gathered primary data from rural households in December. Some variables in our models are dummies. Therefore, the outputs of the OLS and GLM models are undervalued and inaccurate.

Hence, in our study, we employed Poisson and Negative binomial regression to estimate data and then choose which model's outcome was more accurate.

The models can be written as:

Prob Yit = (yit/Xit) = uit e-u it/yityit = 0, 1, 2, 3

We take log of the data to capture the linearity.

Lnuit=αi+ß x1 it+ ß2x2 it ……ßsxsitα+b2x2 it+ b3 x3it+ …..bs xsit

The econometric model shows reduction as a form of health production function and WDL function. The estimating models, we used above are dependent on the data's nature. Previous investigations on health-related disorders have concluded that the medical cost of certain observations is zero. When it comes to estimating, a linearity problem can arise, thus we utilize a Tobit regression model to tackle this problem.

The model is given below:

Mit =α + ß x it +uif the RHS >0

0 Or Else

In the preceding equation, Mit represents the ith household's probability level, which leads to positive mitigation at time T, whereas Xit represents the individual's attributes.

3.3 Empirical Econometric Models

This led to the estimation of two reduced form equations, the Health Production Function (HPF) and the Workday Loss (WDL) function, to assess the marginal effect of ambient dust pollution on human health and utilized the following econometric models to estimate these equations: (Rafiq & Munir, 2014) (Usha Gupta 2006).

H= α1+ ß1pm10+ ß2age+ ß3age2+ ß4sex+ß5edu+ß6ocp+ß7smk+ ß8sh+ß9inc+v

M= α1+ ß1pm10+ ß2age+ ß3age2+ ß4sex+ß5edu+ß6ocp+ß7smk+ ß8sh+ß9inc+v

The dependent variables in the preceding equations reflect Work Day Loss (WDL), which represents how many days labor is ill and switches over due to various diseases linked to ambient dust pollution. It also indicates the number of loss workdays per individual per year.

In the second equation, it signifies Mitigation Cost (MC) which comprises all medical expenses spent owing to dust pollution-related illness, including medicine, transport to doctor clinic, hospital cost, doctor's fee, diagnostic test, hospital stay, and so on each year per person.

The independent variables explained below that affect the mitigation-related activities and health production function which is as follows;

- **Particulate Matter (PM10):** Suspended particulate matter is the harmful matter emitted by the stone crushing industry during the production process. The SPM value was measured in micrograms ug/m3 by skilled technicians from PCSIR laboratories.
- **Age:** Age was represented by a dummy variable. If the individual was between 20 and 60 years, then '0' was assigned. If an individual was less than 20 years or greater than 60 years of age, then '1' was assigned.
- **Age 2:** To check the non-linearity between sickness and age to a minimum. We formed a square of working individuals.
- **Sex:** Sex is represented by 1, if an individual was male; otherwise, it is denoted by 0.
- **Education:** Education is categorical. Education level was measured by assigning different values ranging from 1 to 6.
- **Occupation:** This pertains to one's occupation, and it indicates that those who work have a higher risk of developing various diseases than those who do not work and prefer leisure.
- **Smoking:** Smoking spending is the per month expenditure in Rupees spent by individuals. The cost of cigarettes for smokers was calculated by taking the average price per cigarette.
- **Structure of House:** The variable indicates that those who live in mud houses have a higher risk of disease, whereas those who live in cement houses have a lower risk of illness.
- **Income:** Income was measured in Rupees earned per month by each individual. If the individual was not earning, then it was zero.

3.4 Study Area

This research was carried out in two areas: one in the Jamrud road Shakas area (Crushing market) in the district Khyber, and the other in Regi Model Town Peshawar (without crushing region). We take a 3-kilometer radius from the study region in the crushing area (Herath et al 2012). The economic cost of the disease was compared in each region to determine which region has the highest economic cost of illness. District Khyber is the largest industrial town in Ex-fata Pakistan because the stone-crushing businesses are concentrated in the Shakas Khyber. Khyber is known as the "city of stone." The crushing industry is the backbone of the economy and it plays a critical part in its development and building. On the other hand, Khyber has the ability to utilize energy and a good transportation system both of which contribute to dust pollution. Dust contamination can cause a variety of environmental and health issues. In Khyber, the stone crushing industry is one of the most significant contributors to dust and air pollution.

3.5 Merge Area Profile of District Khyber

District Khyber is an underdeveloped section of the former federally administered tribal area (Ex-FATA) that is bordered by Afghanistan and connected to Peshawar, Orakzai, and Kurram districts. The district's total area is 2,576 cubic kilometers with woods accounting for around 8.22% of the total area. The Jamrud, Bara, Landikotel, and Mallagori are the four tehsils that make up the district Khyber. According to a 2017 demographic survey, the total population of Shakas Khyber is 41216. At the study site, there are 50 crushing plants installed in a residential area.

3.6 Sampling and Data Collection

The primary data was collected for two areas: the stone crushing industry in the Shakas area of district Khyber and Regi Model town Peshawar which served as the control group. With a distance of 3 km, the crushing zone is too dusty and the effect of dust pollution on local people is very strong; whereas primary data was collected within the crushing area's 3 km limit. In addition, 100 households from the crushing region and the identical household from the control group were chosen randomly. The study's goal is to determine the effect of the stone crushing industry and dust pollution on human health. For that, primary data was collected to receive selected household information (Usha Gupta 2006), (Rafiq & Munir, 2014).

Due to time constraints, data collection was limited to one month, i.e. November 2018. The study used the household as a key source for medical and health expenditure data. A cross-sectional household survey was used to quantify the economic repercussions of residing near this crushing region, as well as its influence on individual labor market performance due to workday loss and productivity.

The pollutant-related data were acquired with the help of the Pakistan Council of Scientific and Industrial Research (PCSIR) Peshawar. The ambient dust quality tests were conducted at two points in the target area. During the dry season, the (PCSIR) measures particulate matter PM10 in surrounding communities of the crusher region for 24 hours. They scored two points in both the crushing region and the Control group. After that, PM2.5 would be difficult to locate because it is made up of very fine particles, which are usually found in the pharmaceutical industry. Within a week, the PCSIR provided us the PM10 value, because per point and per day rates are too costly and we are facing financial constraints. The PCSIR could provide an estimate for a specified time.

The primary data for both Workday Loss (WDL) and Mitigation Cost (MC) were collected. The data consist of sampled household information, working individuals, health and medical costs, socio-economic traits, and other factors are included in the data. Many researchers have suggested that the best time to collect data is in the winter (Usha Gupta 2006). (Rafiq & Munir, 2014). Since Crushing Plants are typically operating in the day and night shifts, this period is not just suitable for primary data collection. There is a higher level of dust in the dry season, which affects the entire region, although the amount of dust is low owing to rains. Due to less rainfall in the dry season, dust pollution is at an all-time high from April to September.

Table 01: Descriptive statistics of the household survey

Descriptive Statistics						
Variables	**Number of selected samples is 200, from Crush and Control group.**	**Observation**	**Mean**	**Std. Dev.**	**Min.**	**Max.**
TC	Medical Costs for one month	1278	315.6	1287.05	0	16700
Workday	Workday loss for one month	1278	112.6	518.8	0	12
PM10	Particulate matter	1278	1614.4	1145.5	45	2450
AG	Age of the rural respondent in years	1278	25.0	17.8	.1	80
EDU	Education dummy variable (1 if literate)	1278	1.8	1.3	0	1
SEX	Sex dummy variable (1 if male)	1278	1.4	7355	0	1
SM	Smoke dummy (1 if smokers)	1278	1.9	1438	0	1
OCP	Occupation of the individuals	1278	8.6	3.31	0	1
DS	Distance from Crush to H.H in KM	1278	3.3	3.65	0	1
INC	income of individuals	1278	270.8	477.59	0	3000
SH	Structure of house dummy (1 if cement, o for mud house)	1278	1.8	5123	0	1

The descriptive statistics for the preferred variables are displayed. For the entire month, the Mitigation Cost (MC) ranges from 0 to 16700 PKR. The average monthly medical expense is 94. In a month, the workday loss or opportunity cost averages 12 days. This is especially true for the Crush group which was severely harmed by dust pollution in the environment. The crush group had a very high PM10 concentration of 2450 g/m3, which is exceptionally high for 24 hours. On the other hand, the average level of particle matter is 1247g/m3. Females make up 48% of households, while men make up the remaining 48%. The maximum age is 80 years old, while the youngest is one year old. Smokers account for 26% of the population. Only 32% of the population is educated. We should point out that the literacy rate includes religious education as well as informal education and that literate people are those who can write and read, while, 65 percent of the population lives in mud and stone dwellings. The average daily wage is 270 PKR. Individuals in these two places have jobs at a rate of 17 percent on average.

Table 02: Poisson Model and Negative Binomial Regression

Dependent Variable (WDL)	Poisson Regression		Negative Binomial Regression	
Independent Variables	**Coefficient**	**Std. Err.**	**Coefficient**	**Std. Err.**
Const	-6.76	.0357	-15.49	6.02
PM10	.0003***	8.24	.000061***	.0009
SEX	-1.42	.0128	-.8435	1.02
AGE	.064	.0007	-.1124	.109
AGS²	-.0007	9.83	.0021	.001
SM	.3208	.0028	-3.820	2.03
EDU	-.278	.0092	.285	.385
SH	-.381	.005	-.4525	.497
OCP	-.1776	.0010	-.224	.118
DS	.0002	.0024	- 1.26	.3059
INC	.1193	5.82	.00468	.0011
Log likelihood	-271589.31		-1044.11	
Wald chi	305127.23		58.86	
Total observation	1278		1278	

****, ** and * indicate significance at 1%, 5% and 10% levels*

Table 2 represents the results of the WDL function

WDL function or Health production function

The study's dependent variable was workday loss (WDL), which looked at how many working days people missed owing to dust pollution and related disorders. The health production function was computed using Poisson and negative binomial regression. There are 1278 observations were collected from 200 houses.

Poisson Regression Model

The study key variable Particulate Matter PM10 is positive and statistically significant in the Poisson model. The signals of the two variables have altered and no longer make sense. The coefficient of sex is negative. Males are more afflicted than females, which indicates males are more affected than females. The coefficients of SM and DS are both positive. Negative signals could be seen in EDU and SH. It means that if the house structure is solid, the likelihood of disease is minimal; also as education improves, the number of workdays missed WDL reduces. With a health production function, OCP has a negative coefficient whereas INC has a positive sign.

Negative Binomial Model

The major variable of the study in the negative binomial model is particulate matter PM10 which is positive and significant. So far, the sign of our other variables has been surprising. Other variables positive and negative correlations have discussed above.

Welfare Gains from Reduction in the Work Days Loss

The Poisson regression model could be used to calculate the number of missing days and workday loss in PKR. In the sample group, we must use Poisson regression to estimate the expected value and average employment level. For thirty days, one unit rise in PM10 level can bring and save 0.00000149. According to the findings, the average daily income of working individuals is 600 PKR, while the rate of average working labor in the entire population is 17% of the sample data. The current level of employment can be extrapolated to the entire district. The following is the workday loss calculation employed by (Rafiq & Munir, 2014). (Usha Gupta 2006.)

Restricted days per year: $\alpha * e^{\Sigma \alpha x^*} \Lambda PM10 * 24$

Through the estimate of Poisson regression, the preceding formula depicts the marginal savings of 0.00000149 for thirty days, resulting in a one-unit reduction in PM10. Working people could save 0.37 per day on average over a year. Furthermore, healthy workers may lose output because of illness, but they are still willing to go to work and earn the same wage. All of these illnesses cause employers to lose money and productivity. Reduced productivity should be factored into the cost of illness COI calculation. The sample data revealed that the average wage rate of individuals in the study region is 600 PKR. According to the data, 17 percent of people are employed. The annual benefit of avoiding restricted days is predicted to be 23. According to Poisson Regression, the anticipated benefit to the safe level is 161000/. This is extrapolates to the entire district as a whole.

Table 03: Tobit & OLS Regressions using 1278 Observations

Dependent Variable MC	Tobit Regression		OLS result	
Independent variables	**Coefficient**	**Std. Err.**	**Coefficient**	**Std. Err.**
Const	-6259.68	2874.14	-1038.30	561.41
Pm10	2.26	.525	.28621	.0715
Sex	345.50	283.80	39.07	52.49
Age	152.94	45.74	24.22	7.82
Age^2	-1.54	.6242	-.199	.112
SM	-2356.04	1128.82	-780.57	248.18
Edu	- 474.69	200.98	-43.05	28.53
Sh	36.24	28.27	-58.39	33.24
Ocp	-107.36	69.90	-11.88	13.15
DS	-61.33	149.20	15.90	22.08
inc	.7229***	.539	.0588***	.093
Sigma (u)	4529.32	284.98	R squared	0.07
Log likelihood	-1899.57		-1934.05	
Wald chi 2	164.52 P=0.0000			
Total observation	1278 total observations. Left censored = 1110		1278 number of observations. Left censored = 1110	

Table 3 shows the results of Mitigation Cost (MC)

Demand Function for Mitigation cost

In the above model, the dependent variable is Mitigation Cost (MC) often known as the Mitigation Cost Function. The independent variables are the same as in the workday loss (WDL) function mentioned earlier. The demand for Mitigation cost is estimated using Tobit and OLS regression. The number of observations in this model is 1278.

Tobit Regression Results

Mitigation Cost is the dependent variable in the Tobit regression model and the results are reported in Table 3. The key variable under investigation is Particulate Matter PM10, which is both positive and significant. While the INC and SH structure of the house is also statistically significant. The cost of mitigation for a one-unit change in PM10 is 2.54 units. Other factors' signals may be predicted.

Reduction of Lower Mitigation Cost in the form of Medical Expenditure

To lower the medical costs, we must first estimate the monetary gain and then identify the marginal effect of Tobit regression as shown in table 3. We needed to check the probability of Mitigation cost (MC) and examine the difference in PM10 from the current to safe level due to the Tobit model's calculation. Therefore, it devised a formula to calculate the cost of mitigation (Rafiq & Munir.2014) (Usha Gupta, 2006).

Reduction in Mitigation Cost and saving per annum: ***ß*prob (MC>0)* *ΛPM10* 24**

The average level of particulate matter PM10 in both study locations is 1247g/m3. PM10 concentrations of 150 g/m3 are considered typical (WHO, PCSIR). There is a total difference of 1225 in PM10 levels. We used the above formula to get particle matter PM10 down to an acceptable level. Through Mitigation Cost, each individual could save 4958 PKR each year analyzed by Tobit regression estimation. We assume that the particulate matter PM10 level in Khyber is the same, and hence we find a total welfare gain of mitigation cost for the Shakas district in Khyber. According to a 2017 census, the total population of Shakas Khyber is 41216. Owing to the Tobit regression estimation, the entire welfare gain for Shakas district Khyber is PKR 2453.306 million (2.45) billion.

4. Conclusion

The emissions from stone crushing industries are the main reasons for respiratory, cardiovascular, skin, and eye problems. The most disastrous effect of such emissions is cancer, particularly lung cancer. The monetary cost associated with industrial emissions is evident in this study. A reduction in the SPM level contributes to positive social gains. If the WHO's ambient air quality threshold of 50 micrograms/m3 is followed, an individual will save 4958 PKR per year in mitigation costs. The mitigation cost might be reduced to PKR 2453.306 million or (2.45) billion to reduce dust pollution to a safe level of 150 micrograms per cubic meter. The reduction in workday loss could result in a 161000/ PKR yearly average welfare gain. In addition to the direct benefits of lowering the SPM level, there will be some indirect benefits in the form of reduced workday losses. However, lowering the SPM level has a two-fold effect. On the one hand, it lowers the cost of mitigation; on the other, it raises social earnings.

Hence, the government should develop a clear policy on ambient air quality standards. The current criteria would not even meet the WHO's requirements. Moreover, given the high health costs associated with the emission of SPM into the ambient air estimated in this study, officials should alter the regulations. This is a helpful welfare analysis and we urge the official to adequately handle the situation to close the welfare gaps. Otherwise, industries can implement technologies to reduce SPM emissions.

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