OCCUPATIONAL DISEASES AND THEIR DETERMINANTS
A STUDY OF COAL MINE WORKERS IN WEST BENGAL

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Abstract

In recent years theoretical and empirical is focussing on occupational health hazards in industries like gemstone, lime, etc. In this paper the focus is on one such industry – coal.

We seek to examine the nature and magnitude of occupational diseases in coal-mining. The socio-economic and technological factors determining the incidence of occupational diseases on workers is also identified using a Tobit model. Finally, the implications of the findings of this paper for designing an optimal health care strategy have been stated.

The work is based on a survey of three coal mines in the state of West Bengal, India.

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1. Introduction

Over several decades environmental problems have being drawing the attention of research workers, policy makers and civil rights activists all over the world (Brandon & Kirsten, 1995). While the initial focus was on externalities generated by production activities, it has also been pointed out that those engaged in various capacities *within* the industry can also be affected. Such occupational hazards are common in industries like mining, limestone, gem cutting, etc. One of the most hazardous industries is coal mining. The unhygienic working conditions in underground mines create health hazards for the mineworkers and have a major effect on their health. The problem is especially serious in view of the economic importance of coal mining in India – as a source of energy, in terms of its contribution to GDP, and as a major provider of employment.

This paper examines the extent and nature of occupational diseases in three mines in West Bengal. The determinants of occupational diseases in these mines will also be identified. This study can be summarised in terms of three hypotheses as follows:

1. *Primary Hypothesis:* Mine workers have poorer health than other sections of the population. Health is measured in terms of proportion of diseased persons in a particular group (i.e. mine-worker and non-mine-worker) and the number of disease episodes that individuals suffer from.
2. *Secondary Hypotheses:*
   - 2.a. Mine workers are more likely to suffer from certain diseases (specified later).
   - 2.b. Health of the worker is affected by socio-economic factors like educational level, family size, income, place of work, period of exposure, and salary group.
   - 2.c. The technology employed is another important factor affecting health of the workers.

Finally, in the concluding section, the results of the survey will be used to suggest how an optimal health care strategy can be designed.

2. Research on Occupational Hazards in Coal Mining in India

Research by economists on occupational hazards and their burden on the affected class is of recent origin in India (Brooks, 1987). In the few such studies the hospital admission and cause of death statistics from the hospital records have been used to create the disease profiles. For instance, the National Sample Survey Organization collected community level information on hospitalised episodes in its 42nd round sample survey during 1989-90. Subsequently in 1990 the National Council of Applied Economic Research (Shariff, 1995) collected community level data on treated illness. However, such information does not truly reflect the incidence of disease, as a large proportion of disease episodes may be untreated.

There are instances of similar studies for the coal mining industry. The West Bengal State Pollution Control Board undertook a study in 1984-85 to study the incidence of diseases among the indoor patients in the major hospitals of the Asansol-Raniganj industrial area (Ghosh et al, 1997). This study revealed the high incidence of infectious colitis, enteritis and gastro-enteritis, diabetes mellitus, schizophrenic psychoses, hypertension-related heart diseases, asthma, rheumatoid arthritis, cataract, acute bronchitis, etc.

In a joint study by the Indian Council of Medical Research and the International Development Research Centre, Canada (ICMR & IDRC, 1993) in the Raniganj coal field area of West Bengal the following facts were observed:

(a) The dust levels in all underground coal mines included in the study were higher than the suggested threshold limit value (TLV).
(b) The prevalence of pneumoconiosis in underground coal miners was 2.84% while in the case of surface coal workers it was 2.10%.
(c) About 40% of the cases of pneumoconiosis in underground coal miners and 20% in surface coal workers showed irregular (linear) opacities on chest X-rays.
(d) The prevalence of chronic respiratory symptoms amongst the underground miners was 31.3%, which was significantly higher than that amongst the surface coal workers (17.0%).
(e) The overall prevalence of functional abnormalities of lung in underground coal miners and surface coal workers was 45.4% and 42.2% respectively.

(f) In underground coal mines the noise levels were higher than the standards prescribed by Director General of Mines Safety (DGMS). This can create ENT related problems.

(g) The thermal environment in the underground mines was found to be non-conducive for heavy and moderate physical work as evidenced from Wet-Bulb-Globe-Temperature (WBGT) index.

(h) The wind velocities at the working faces in underground coal mines were found to be either low or stagnant**.**

However, these studies have focussed on the disease profile only. They have not attempted to link such health problems to working conditions in the mines or to identify the socio-economic factors determining the prevalence occupational diseases. This study addresses both these problems.

3: Database and Methodology

The present work is empirical in nature. The data used in this work is primary in nature and has been collected from three mines in West Bengal. These mines are Pandaveswar Underground mine, Khottadih Underground Project and Khottadih Opencast Mine. The mines selected are located in the Ranigunj Coal area, which is one of the richest and oldest coal mining areas in India. They are under the administrative jurisdiction of the Pandeveswar Area Office under the Eastern Coalfield Limited. Each of these three mines employ a different technology. This enables us to study variations in health problems caused by different technologies.

The data was collected through face-to-face interviews using a household-based questionnaire. The sample size of our study was 15% of the total work force. The sampling method used was stratified purposive method. The mining work force can be divided into various categories based upon place of work, job responsibility, etc. Now, as the technology employed by the survey mines is different, it is not easy to find a common classification of workers. The only common categorisation was the nature of the wage contract. Workers are divided into three groups: Monthly Rate workers, Time Rate workers and Piece Rate workers. Our sample takes 15% of the work force from each category. This enables us to obtain a representative sample from the mine workers.

Table 1: Total Work Force and Sample Size

Name of Mine	Total Work Force	Sample Size
Pandeveswar Underground Mine	1480	222
Khottadih Underground Mine	1780	267
Khottadih Underground Mine	547	82

Two types of statistical methods has been used to analyse the survey data. On one hand, tabular and diagrammatic methods have been used to present relationships between two or more variables. More sophisticated techniques, in the form of regression models, has also been used to test the hypotheses of this paper. In addition to the standard Ordinary Least Square method of estimation, Logit and Tobit models have also been used.

4: Incidence of Disease amongst Mineworkers and Non-Mineworkers

We start with the main hypothesis of this paper – that the incidence of diseases is higher in mineworkers.

4.1: Comparison with All-India and State Data

The frequency of persons suffering from occupational diseases as found in the survey is compared with similar data obtained for West Bengal and India. These figures have been obtained from a study conducted by NCAER (1998). It can be seen that the proportion of mine workers who are ill is significantly higher in compared to all-India and West Bengal levels. If we compare the non-mineworkers of our surveyed group, then the percentage of ill persons is slightly higher compared to the state and the national figures. This may indicate a negative externality operating on residents of mining areas. Surprisingly, these figures are low for females. This may be because male members work in areas close to the mine and it is on them that the incidence of the externality falls.

Table 2: Percentage of Affected Individuals

Place	**Male**	**Female**	**Total**
All India	10.55	10.81	10.67
West Bengal	7.78	8.72	8.20
Non-Mineworkers	20.37	7.98	14.86
Mineworkers	89.10	90.00	89.13

(Source: All India and State level figures are from NCAER, 1998; the remaining estimates are based on survey results)

We now turn to a comparison of different groups in the surveyed area. The prevalence of diseases has been measured through two indicators – the number of individuals suffering from any disease and the number of diseases that any person is suffering from.

4.2: Number of Affected Persons

We first consider the number of persons suffering from each disease group. It can be seen, from the Table given below, that the mineworkers share the major burden in each disease group. The incidence of diseases is significantly lower for family members, and also for workers in the non-mining sectors. This implies that mining has a significant effect on the health of the worker.

Table 3: Percentage of Mineworker and Non-Mineworkers Affected by Any Disease

Groups of Diseases	Pandeveswar Underground Mine			Khottadih Underground Mine			Khottadih Opencast Mine		
	Mine Worker	Non Mine Worker	Family Member	Mine Worker	Non Mine Worker	Family Member	Mine Worker	Non Mine Worker	Family Member
Lung related	46.85	0.00	5.26	47.94	6.93	8.39	48.81	0.00	8.92
Pain	62.16	0.00	1.26	44.19	0.99	1.76	54.76	0.00	1.54
Intestinal Infections	35.14	0.00	3.16	34.08	2.97	3.28	20.24	0.00	3.38
Tension Related	20.27	0.00	1.05	23.60	3.96	3.36	17.86	0.00	2.15
Influenza	14.41	0.00	4.53	17.98	0.99	2.56	17.86	0.00	4.92
Chest Pain	12.16	0.00	0.42	7.49	0.00	0.96	22.62	0.00	0.62
Dermatological	14.86	0.00	0.53	5.62	0.00	0.32	10.71	0.00	1.23
Miscellaneous	10.81	2.30	4.32	14.23	1.98	2.80	15.48	0.00	7.38

4.3: Disease Episodes

Another indication of the presence of health hazard is the number of disease episodes in the survey period. The number of disease episodes is higher for workers, compared to that for non-workers and family members.

Table 4: Average Disease Episodes

Mine	***Mineworker***	***Non Mine Worker***	**Other Family Members of the Mineworkers**
Pandeveswar Underground Mine	2.7	0.19	0.64
Khottadih Underground Mine	2.4	0.25	0.60
Khottadih Opencast Mine	2.5	0.26	0.71

4.4: A Statistical Model of Occupational Health Hazard

The above analysis indicates that the incidence of diseases is much higher for mineworkers. In this section this proposition is tested using regression analysis.

We start by regressing the probability that a person is ill on whether he is a mineworker or not. The null hypothesis will be that an individual is not more likely to be ill if he is a mineworker. Now occupation is a qualitative variable. This implies that a dummy has to be used for the independent variable. As a matter of fact, all occupations will not be considered – but only mining is considered. So, the dummy variable will be:

MW = 1 if the person is a mineworker.

= 0 if the person is not a mineworker,

Now the dependent variable (ILL) is also a dummy variable - with values of 0 (for a healthy individual) and 1 (for a person with any type of health problem). This implies that a Logit model has to be used to estimate the relation between MW and ILL.

The results of the logit models are given below:

Table 5:Results of Logit Model

Statistic	**Pandeveswar Underground**	**Khottadih Underground**	**Khottadih Open Cast**
Intercept	-2.06	-1.75	-1.63
t-ratio of Intercept	-21.01	-22.83	-11.06
Coefficient of MW	4.69	3.85	4.30
t-ratio of MW	16.46	18.25	9.56
Log likelihood ratio	-420.32	-660.11	-173.86
Rest.Log likelihood	-717.96	-946.15	-261.44
McFadden's R^2	0.41	0.30	0.33
Count R^2	0.90	0.85	0.85
Chi-square	595.28	572.07	175.16

The Chi-square is higher than the tabulated value in all cases. This indicates that the null hypothesis holds. The sign of MW is expectedly positive; the t-statistic is also statistically significant.

Now, in the above analysis all types of illness had been considered. However, there are some diseases that typically affect the mineworkers: lung-related diseases, general body pain, intestinal infections, chest pain and dermatological problems (ICMR & IDRC, 1993). Illness can therefore be redefined to include only these symptoms. Based on this new definition a new variable, ILLM, is defined as follows:

ILLM = 1 if the individual suffers from any of the above symptoms

= 0, otherwise.

The earlier logit model is re-run, using ILLM as the dependent variable instead of ILL.

Table 6:Results of Logit Model

Statistic	**Pandeveswar Underground**	**Khottadih Underground**	**Khottadih Open Cast**
Intercept	-2.08	-2.06	-1.60
t-ratio of Intercept	-21.05	-24.06	-10.99
Coefficient of MW	4.45	3.69	3.86
t-ratio of MW	17.15	-19.93	9.66
Log likelihood ratio	-426.15	-588.08	-177.81
Rest.Log likelihood	-711.53	-870.21	-261.44
McFadden's R^2	0.40	0.32	0.32
Count R^2	0.89	0.88	0.85
Chi Square	570.76	564.26	167.28

The high value of Chi-square statistic indicates that the model is acceptable. Simultaneously, the coefficient of MW is positive and significant. This indicates that the probability of an individual suffering from any of the above diseases is dependent upon whether he is a mineworker.

The third indicator is now considered - the number of diseases that the respondent is suffering from. The model regresses MW on the number of disease episodes (DIS). Now persons who vary in their healthiness but have not suffered from any disease episode are all classified together and assigned a value of 0. This implies that the value of the dependent variable (DIS) is censored at 0. In such cases a Tobit model should be used to generate maximum likelihood estimates. The Primary Index Equations of the Tobit Model for the three mines and other relevant statistics are as follows:

Table 7: Results of Tobit Model

Statistic	**Pandeveswar**	**Khottadih Underground**	**Khottadih Open Cast**
Intercept	-2.19	-2.07	-1.67
P-value of Intercept	0.00	0.00	0.00
Coefficient of MW	4.88	4.38	4.11
P-value of MW	0.00	0.00	0.00
Sigma (Std. Dev. of Disturbance)	1.97	2.16	1.91
Prob of Sigma	0.00	0.00	0.00
Log likelihood	-956.076	-1373.018	-381.4329
Number of observations	1259	1619	420

The results of this exercise again support the primary hypothesis that the disease episode (DIS) on an individual will be related to whether he is a mineworker or not. The sign of the coefficient of MW is positive – implying that the disease episode on a person will be greater if he is a mineworker. The probability-values of the coefficients are both significant.

5: Disease Profile of Mine Workers

Having established the primary hypothesis we now attempt to identify the nature of occupational diseases affecting mine workers. In this attempt the low level of literacy and consciousness amongst workers created a problem. The workers were not always able to identify the diseases from which they were suffering from –instead they often described their symptoms. In such a case, a medical examination of the worker becomes necessary to identify the particular disease from which he was suffering from. However, practical problems constrained such a first best solution. Instead the second best solution was chosen; both aspects were considered– diseases and symptoms.

Table 8: Incidence of Disease Amongst Mineworkers

Disease	Percentage of Affected Mineworkers		
	Pandeveswar	Khottadih Underground	Khottadih Open Cast
Body pain	98.23	96.81	90.48
Blood sugar	75.00	50.00	40.00
Breathing problem	76.09	74.07	69.23
Chest pain	87.10	62.50	90.48
Cold Cough	68.03	75.40	1.72
Ear	75.00	58.33	100.00
Eye	57.89	67.57	62.50
Gastritis	79.37	73.47	62.50
Gout	83.72	45.45	70.00
Headache	90.63	75.00	84.62
Vertigo	47.37	62.50	66.67
High Blood Pressure	75.00	57.14	75.00
Influenza	42.67	59.26	48.39
Intestinal Infection	63.79	58.49	50.00
Low blood Pressure	40.91	43.64	37.50
Lowbackach	95.83	94.44	93.55
Skin infection	86.84	78.95	69.23
Spondeliti	90.00	88.89	100.00
Tuberculosis	63.64	83.33	50.00
Whooping cough	80.00	72.41	0.00
Miscellaneous	22.22	27.59	27.59

It can be seen that body pain and backache in the lumbar region trouble a large proportion of workers. This originated due to the strenuous manual nature of their duties. In addition, influenza, gastritis, breathing problems, chest pain, common cold, and intestinal infections are common diseases.

An interesting finding is that the prevalence of diseases is higher amongst workers in the Khottadih Underground mine. The prevalence of diseases also varies across the mines to some extent. For instance, problems like pain in the body and lumbar region, cold, breathing problems, common cold, gastritis, and flu is common to all the mineworkers. However, some diseases like whooping cough, low blood pressure, ear and eye related problems are more common amongst workers in the Khottadih Underground mine.

5.1: Identification of Disease Categories

Now, the number of diseases and symptoms are too large to make a meaningful comparison. So, the diseases have been classified into distinct categories to facilitate comparison. The groups are stated follow.

Table 9: Classification of Diseases and Symptoms

Name of Group	**Diseases and Symptoms in Group**
Lung related	Asthma, Breathing Problem, Cold Cough, Tuberculosis, Whooping Cough.
Pain	Body pain, Gout, Low back Ache, Spondilosis.
Intestinal Infections	Gastritis, Intestinal Infection
Tension Related	Blood Sugar, High Blood Pressure, Low Blood Pressure, Headache, Vertigo.
Influenza	Fever
Chest Pain	Chest pain
Dermatological	Skin infection
Miscellaneous	Accident, Diabetes, Ear, Eye, Jaundice, Neurological problem, Polio, Renal problem, Surgical cases, Thyroid, Typhoid

Using this classification of diseases, the incidence of diseases amongst workers in the three mines will be examined.

Table 10: Disease Profile of Coal Mine Workers (in Percentage)

Group of Diseases	Pandevaswar Underground	Khottadih Underground	Khottadih Open Cast
Lung related	48.37	47.94	50
Pain	64.18	44.19	56.09
Intestinal Infections	36.28	34.08	20.73
Tension Related	22.33	25.09	23.17
Influenza	14.88	22.33	18.29
Chest Pain	12.56	7.49	23.17
Dermatological	15.39	6.98	10.97
Miscellaneous	11.16	17.67	15.85

The two main disease groups are lung related ailments and different types of body pain. The incidence of intestinal infections and tension related diseases are also high. In the Khottadih Open Cast Mine, however, chest pain is a common problem.

6: Factors affecting Health of Mineworkers

Having established that mining exposes the workers to health problems and adversely affects their health, it is necessary to identify the factors influencing health of the mineworkers.

It is hypothesised that the following seven factors can affect health of mineworkers.

1. Level of education of the respondent;
2. Family size;
3. Income of the mineworker;
4. Salary group to which he belongs;
5. Place of work of the worker; and
6. Exposure to the mining environment;

In the following sections an attempt will be made to examine whether and how these factors affects health of mineworkers.

6.1: Level of Education

Education can play an important role in determining the health status of an individual. Generally, the more educated an individual is, the more conscious he is of the various health hazards to which he is exposed to and their associated costs. This creates an impetus to maintain health. In the case of the mineworkers, this variable may not be important. The reason is that the worker has to work in an environment that is unhygienic and fraught with health hazards.

6.2: Family Size

Family size can also have an influence on the health of a worker. A large family size may affect his health in two ways:

1. It may create insanitary domestic environment;
2. It may reduce the family capability to spend on health care of the mineworker.

6.3: Income

Income of the respondent can affect the health of the mineworker in several ways:

1. As income rises, standard of living will improve. This will induce better health conditions at the residence of the worker, which will compensate (partially) for unhygienic working conditions.
2. Higher income will generate greater health consciousness. The worker will be aware of the utility of possessing good health and the implications of working conditions for hygiene. The worker will deliberately take steps to maintain his health.
3. A high paid worker is more likely to be in a high post – in the office, away from the unhygienic conditions below the surface.

All these forces create a positive relation between health and income of the worker. But it is also possible that a high paid worker is occupied in an activity that may involve not physical strain, but mental anxiety due to the heavy responsibilities of his position. This is particularly true for managerial posts. This may counterbalance the above forces. Further high income may also be a result of having served for a longer period in cola mines. In such cases high income is associated with a longer period of exposure to the mining environment and can be expected to affect health adversely.

6.4: Salary Group and Health

Another important determinant of the health of the worker is the responsibilities of he workers. There are about 50 different categories associated with different types of jobs involved in the mining process. One way to categorise them is by salary groups. There are three such salary groups:

1. *Monthly Rate Workers:* A fixed monthly salary is paid to workers in this group. This group consists of managers, executives, clerks, etc. – basically 'white collar' workers. These workers are engaged in duties within the office of the mine and are not exposed to the unhygienic conditions down the shaft. We can expect that the health profile of these workers will be best.
2. *Piece Rate and Time Rate Workers:* These two rate structures mainly include different categories of miners who are directly engaged in the coal mining process. Piece rate workers include loaders and trammers who are paid according to the quantity of coal handled by them. These workers are most exposed to health hazards of coalmines. The remaining workers are classified as time rate workers. They are paid according to the number of days they work in a month.

6.5: Place of Work and Health

Health of the worker depends on his working environment and, in the case of mines, this depends upon the place of work. A priori, therefore, it can be expected that the place of work of the worker will have a significant effect on the health of the worker.

Now, in the case of underground mines, the production phase can be divided into two classes of activities:

1. Activities directly related to the extraction and processing of coal for dispatch. These activities can be divided into underground and surface activities.
2. Other supportive activities consisting of financial and managerial responsibilities. Obviously, this class of activities is undertaken within the office on the surface.

On the other hand, open cast mining is carried out on the surface. A different method of categorisation has to be adopted for the open cast mine. Now, in such mines, the production process is capital intensive. Here, in addition to the group of workers who are involved in extraction of the coal operating machines, a part of workers are occupied with servicing and maintaining of the machines uses for the mining process. Finally, there is a third group consisting of office workers.

6.6: Period of Exposure to Mining Environment

Another factor that can be expected to affect health of the worker is the period of exposure to the unhealthy conditions in the mine. The longer the period of exposure the more he is likely to be affected, and the more serious his problems are likely to be. The experience of the worker – the number of years he has worked in the mining industry - has been chosen as a proxy for exposure.

6.7:Technological impact on Occupational Health Hazards

Last, but certainly not the least, the choice of technology may affect the health of the worker. In the three mines surveyed three different technologies are used. Pandeveswar and one of the Khottadih mines are underground mines, while the other Khottadih mine is an open cast mine.

The technology in the Khottadih open cast mine is more mechanised in nature; further, the work occurs in the open air under the sky. This may generate greater environmental hazards, but less local health hazards. On the other hand, Pandeveswar and Khottadih underground mines are basically labour intensive and are less dependent on the heavy machine power, extracting coal from the underground tunnel, in a much more congested atmosphere. So that health hazards are more likely in these underground mines than in the mechanised open cast technology.

Again, among the underground mines Khottadih mine is more machine intensive in nature and therefore it could be expected that prevalence of the health hazards of the mineworkers is less than the primitive underground mine, Pandeveswar.

6.7.a: A Statistical Model of Technology-Health Relationship

To test the proposition that technology plays an important part in determining health of the workers, a regression is estimated on pooled data. Since all the workers are ill, it is not possible to take illness as the dependent variable. On the other hand, expenditure pattern can vary across regions so that relating technology to medical expenditure may give erroneous results. Therefore we use the number of disease episodes (DIS) as the dependent variable. Two dummies are taken – PDV (=1 for respondents working in the Pandeveswar mine, 0 otherwise) and KUG (=1 for respondents working in the Khottadih Underground mine, 0 otherwise). It is expected that the coefficients of both PDV and KUG will be positive. Note that as DIS is censored for values below 0 the Tobit model is used.

The Primary Index equation of the Tobit model is:

DIS = 2.46 + 0.25 PDV - 0.13 KUG

(0.00) (0.2006) (0.4956)

Sigma (Disturbance standard deviation) : 1.50 (0.00)

Log likelihood function: -1020.052 n=573.

The low probability values of the coefficients of PDV and KUG indicate that the number of disease episodes affecting the mineworkers in these mines is not significantly different from that of the mineworkers of the Open Cast mine. This is rather surprising.

6.7.b: Labour Intensity and Occupational Diseases

Another possible way in which technology may determine the extent of health hazards is through the capital intensity or degree of mechanisation of the extraction process. The greater the degree of mechanisation, the lesser will be the health hazards faced by the workers. Now, Pandeveswar uses a primitive labour intensive technology, while both the Khottadih projects are much more mechanised. So the mines are clubbed into two groups on the basis of a new variable, INTENSITY:

INTENSITY = 0 for the Khottadih projects

1 for the Pandeveswar project

It is expected that DIS will be positively related to INTENSITY. The results are as follows:

DIS = 2.36 + 0.35 INT

(0.0) (0.0077)

Sigma (Disturbance standard deviation): 1.51 (0.00)

Log Likelihood Function: -1020.284;n=573.

This model yields a better result than the earlier model. The sign of INTENSITY is as expected; its probability value is high. Therefore, it can be argued that the extent of mechanisation – rather than the technology used – which is a significant factor affecting health hazards in the coal mining industry. If it is labour intensive underground mine then the occurrence of the health hazards will be high.

7: A Statistical Model of Factors Determining Health of Worker

In this section the impact of the above seven factors on the incidence of occupational diseases amongst mineworkers will be examined. Like the preceding analysis regression models will be used to verify the propositions made above. Unlike the earlier analysis the likelihood of a person being ill can no longer be used as the dependent variable. This is because all the mineworkers are ill – there will not be any variation in the dependent variable. Instead the disease index (DIS) – the number of diseases the worker is suffering from – is used. This implies that the Tobit model will have to be used.

7.1: Results of Tobit Model

The estimated Tobit equation is:

$$\mathbf{DIS = \lambda + \eta_1\, EDU + \eta_2\, TM + \eta_3\, IT + \eta_4\, MONTH + \eta_5\, EXTRACT + \eta_6\, PDV + \eta_7\, EXP}$$

where EDU = Educational level of respondent

TM = Family size

IT = Family Income

MONTH = 1 for Monthly Rate workers

= 0 otherwise

EXTRACT=1 for respondents engaged in process of extraction of coal

= 0 otherwise

INTENSITY = 0 for the Khottadih projects

=1 otherwise

EXP = Experience in coal mining industry

η_i 's are the coefficients of the explanatory variables.

The results of the Tobit model are given below.

Table 10: Determinants of Disease Episode in Pooled Data

Variable	Coefficient	Probability
Constant	2.49043	0.0000**
TM	-0.10114	0.0021*
EDU	-0.25398	0.0000**
IT	0.000023	0.0197*
EXTRACT	0.32635	0.0085*
MONTH	-0.12605	0.5534
EXP	0.03521	0.0000**
INTENSITY	0.01953	0.8761
Disturbance St. Deviation	1.37716	0.0000
Other statistics		
Log Likelihood Function	-973.5581	
Observations	573	

(Asterisk marks denote statistically significant coefficients)

The values of five coefficients are statistically significant – TM, IT, EDU, EXTRACT and EXP. The signs of EDU, EXTRACT and EXP are as expected. The sign of IT is positive – indicating that as income increases disease episodes will increase. This can be explained as follows. High income may be due to the high post of the respondent. It may, however, also be a result of a long period of service in mining industry. In the latter case, high income will be associated with a high number of disease episodes. The negative sign of the coefficient for TM is also not as hypothesized. One possibility is that in a large family, the income is shared between a larger number of individuals. The share of each member is low, so that they cannot tolerate any further fall in consumption due to the ill health of the mineworker. Therefore, they seek to insure their consumption levels by providing better health care to their bread earner. This may be the reason for the negative sign of the coefficient of TM.

The high probability value of INTENSITY is surprising when the earlier results relating INTENSITY with DIS considered. Although, INTENSITY is satisfactory when taken individually, it looses its explanatory power when other variables are introduced into the analysis. This is surprising, as theoretically a high correlation between INTENSITY and the other variables is not expected *a priori*. Empirically, the correlation coefficient between INTENSITY and EDU is quite high (-0.25652). The reason for the high correlation between INTENSITY and EDU lies in the mechanised nature of the technology in the Khottadih mines, especially in the Open Cast mine. The nature of the technology requires a more educated work force, compared to the work force in the Pandeveswar mine. The recruitment policy in these mines resulted in the use of a more educated workforce in these two sites. This generates a strong negative association between labour intensity of extraction process (INTENSITY) and educational level of the mineworkers.

Another variable with which INTENSITY is highly correlated is EXTRACT. The correlation coefficient is -0.29982. This is somewhat surprising. One explanation may be that the Pandeveswar mine employs a larger work force than the other mines; further in this work force a larger proportion is engaged in the process of extraction of coal.

Similarly, the absence of any significant relation between disease episodes and salary group can be explained in terms of multi-collinearity between MONTH, and EDU and IT. Monthly rate workers are more skilled and educated. Hence they have a higher income. On the other hand, they are generally engaged in management level jobs and can thus be expected to be more experienced. The correlation coefficient between MONTH and IT is 0.35114 and between MONTH and EDU is 0.4607.

7.2: Determinants of Occupational Diseases in Mines

Finally, the factors determining the incidence of disease episodes are considered for each mine. In the following table the statistically significant coefficients are presented that are for that particular mine.

Table 11: Determinants of Disease Episode in Three Different Mines

Variables	***Pandeveswar Underground Mine***	***Khottadih Underground Mine***	***Khottadih Open Cast Mine***
EDU	-0.321	-0.191	-0.174

TM	-0.190	-	-
IT	.00003	0.244	-
MINING	X	X	-
UGROUND	0.372	0.297	X
MONTH	-	-	-
EXP	0.321	0.505	-
Sigma	1.299	1.386	1.387
LLF	-366.7924	-448.7442	-143.79
N	222	267	84

The above table indicates that educational level of the respondent affects the incidence of disease episodes in all the three mines. Other important factors are experience and income. In the Pandeveswar and Khottadih Underground mines, the place of work is also important.

7.3: Determinants of Occupational Disease in Underground Mines

Now, the model for the Open Cast mine is not statistically significant. So another pooled equation, clubbing together the underground mines. The regression results of this equation are as follows:

Table 12: Determinants of Disease Episode in Two Underground Mines

Variables	Coefficients	Probability
Constant	2.27	0.00**
IT	0.000022	0.02*
TM	-0.0945	0.01*
EDU	-2.4	0.00**
UGROUND	-0.226	0.33
MONTH	0.35	0.05*
EXP	0.043	0.00**
PDV	1.99	0.24

Sigma	1.37	0.00**
Log likelihood function	-824.9255	
Observations	489	

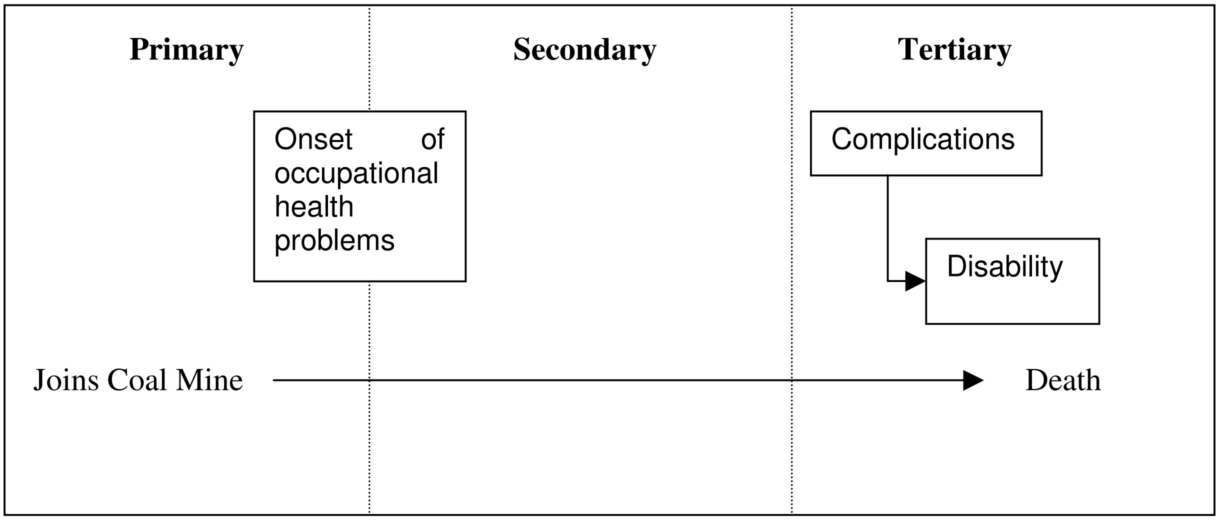
The results of this equation indicate that disease episodes are positively related to IT, UGROUND and EXP; it is negatively related to TM, and EDU. Possible explanations of these signs have been given earlier. Two points are important here. Firstly, MONTH is again insignificant as it is highly correlated with IT (0.30114) and EDU (0.47492). Secondly, there does not appear to be any significant difference in the number of disease episodes in the lives of workers in the two underground mines.

8: Policy Implications of Findings

Four facts has been established in this analysis. First, mining does pose significant health hazards on the worker. Secondly, pulmonary diseases, pain related diseases and intestinal disorders have been identified to be the major ailments affecting mine workers. Thirdly, this health hazard increases with exposure to the mining environment; it also depends upon income, family size and educational standards of the respondent. Workers working underground are also susceptible to health hazards. Fourthly, the nature of the technology uses in the extraction of coal is an important determinant of the health hazards. The episode of the diseases decreases when the technology became more capital intensive. In this section we shall examine the implications of these findings in designing a better health care strategy.

Opportunities for prevention exist at three different levels, as defined below and shown in Figure 6.1 (WHO, 1994).

Figure 1: Alternative prevention strategies and their consequences



a) *Primary Prevention:* This covers activities aimed at preventing occupational diseases from occurring in susceptible individuals through modification of environmental and behaviour-related risk factors. In practice this includes any activity undertaken prior to development of clinically evident occupational diseases. There are two types of primary prevention:

   i) Activities targeted at reducing the frequency or level of the causal risk factors for development for occupational diseases in whole populations or categories of workers exposed to occupational hazards.

   ii) Activities targeted at preventing the full clinical expression of diseases in specific workers who are already manifesting early symptoms of the disease.

b) *Secondary Prevention:* This covers activities such as screening, which aim at early detection of occupational health hazards and prompt an effective management of the condition with the purpose of reversing the disease and/or halting its progression. In practice this involves any strategy aimed at the detection of as yet diagnosed cases of health hazards.

c) *Tertiary Prevention:* This is any measure undertaken to prevent complications and disability due to health hazards; I.e. to prevent or delay the negative health consequences of occupational health hazards amongst workers who have already developed the disease. In practice this means early detection, effective management, education, etc.

There are basically two broad ways to orient the preventive strategy:

a) *Population approach:* Activities are aimed at modifying the levels of causal risk factors for the entire labour force, without regard to the specific level of risk of the individual. This includes various environmental control methods (like shifting to open cast techniques, provision of better working conditions underground) and attempts to alter some of the behavioural patterns of the workers (using safety gear, not drinking the underground natural water).
b) *High Risk approach:* Intervention is targeted selectively at groups of workers who are identified as being at elevated risk of the disease and hence receive special attention.

The management should not try to choose between these strategies – the two strategies are complementary. Hence the management should attempt to seek the appropriate composition of a unified health strategy combining both these strategies. The population approach is suitable in the prevention of diseases commonly afflicting mine workers; on the other hand, some diseases affect workers selectively, depending upon the nature of their job. In such cases, the high-risk approach is more appropriate. In other words, if the risks are spread broadly throughout the labour force, the population approach is the more logical. However, if risk factors tend to cluster in certain categories of workers the high-risk strategy will be more cost effective.

This implies creation of a pyramidal health care structure. We had observed that pulmonary diseases, dermatological problems, intestinal infections and pain related problems are the most common ailments. A population approach is more appropriate for these categories of diseases. The local Health Centres established in each mine should have all the necessary facilities for diagnosing and treating these diseases. On the other hand, the treatment of diseases like ophthalmic problems, advanced stages of tuberculosis, surgical intervention and treatment of accident injuries should be undertaken at Hospitals established in Head Offices.

The optimal health strategy should also aim at modification of behaviour patterns (using gas masks, Wellingtons, Davy lamps, etc.) through promotion of awareness of health hazards and its consequences. Among other methods is provision of safe drinking water to underground workers, etc. A change in intensity to a more mechanised form of coal extraction will also reduce occupational hazards significantly. However, some of these measures may provoke resentment among the workers themselves. For instance technological changes may be resisted by trade unions as they reduce the size of the labour force.

Simultaneously, the management should also introduce an effective screening strategy. At present, the management does provide facilities for medical check ups. But they are undertaken cursorily at intervals of 3-4 years. Further, this screening process adopts a uniform check up procedure for all workers. Instead a case specific approach should be adopted that takes into account the risks faced by the individual worker. Two indicators of high risk are important in this context – period of exposure to mining environment, and place and/or nature of work (underground workers and those engaged in extraction of coal are susceptible to occupational health hazards).

In this context it should be noted that in all the three mines the number of disease episodes is increasing for mineworkers with more than 5 years of experience. Therefore primary prevention strategies should be directed towards this group. As the experience of the worker increases, intervention should shift to a greater reliance on secondary strategies. This involves more frequent check ups to enable detection of the disease before its clinical manifestation. Workers with longer experience will require a tertiary prevention strategy. This involves controlling the progress of a diagnosed disease through medical treatment and periodic reviews.

Among other categories of workers facing high risks are those working underground or those engaged in the extraction of coal (in the case of open cast mining). These workers mainly suffer from pain related problems, intestinal infections and, especially, lung related ailments. The high-risk approach suggests that these categories should be singled out for special attention – regarding check up, treatment and in evaluation of progress of the diseases.

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