Health Care Expenditure of Coal Mine Workers: A Case Study in West Bengal

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In recent years attention has been increasingly drawn to environmental problems caused by industrial and consumption activities. While theoretical and empirical literature has focused on mainly externalities generated by such activities, the effects of production on the workers may also be significant. Such health hazards are prominent in labour-intensive industries like gem cutting, limestone and mining.

In this paper the focus is on the coal industry. The nature of coal mining is such that one would expect that the workers engaged in the mining process suffer from various ailments. This paper seeks to examine the magnitude of the burden in terms of health care expenditure caused by such hazards. The authors also seek to identify the factors determining the health care expenditure on workers. The work is based on a survey of three coal mines (using three different types of extraction technologies) in the state of West Bengal, India.

Introduction

Over the several decades environmental problems have being drawing the attention of research workers, policy makers and civil rights activists all over the world (Brandon and Kirsten 1995). In the context of industrial activities it has been pointed out that they generate externalities that affect not only residents unconnected with the industry, but also those engaged in various capacities within the industry. Such occupational hazards are prominent in industries like mining, limestone and gem cutting. For instance, coal mining can generate various environmental problems like depletion of the ground water-table, water

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pollution, air pollution, noise pollution, land degradation, land subsidence and emission of methane. The adverse and unhygienic working conditions in underground mines may also lead to health hazards for the mine workers and their family members living in the vicinity of the mines.

Research by economists on such occupational hazards and their burden on the affected class is of recent origin in India (Brooks 1987). In the few such studies hospital admission and cause of death statistics from hospital records have been used to highlight disease profiles. Such information does not truly reflect the burden of diseases and sicknesses of the community. For instance, the National Sample Survey Organisation 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 (NCAER) collected community-level data on treated illness.

With respect to coal mining, a survey was conducted by the West Bengal State Pollution Control Board in 1984–85 to study the incidence of diseases among 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 gastroenteritis, diabetes mellitus, schizophrenic psychoses, hypertensive heart diseases, asthma, rheumatoid arthritis, cataract, acute bronchitis, etc. However, this study fails to link such health problems to working conditions in the mines and identify the factors associated with such diseases.

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

1. The dust levels in all underground coal mines included in the study were higher than the suggested threshold limit value (TLV).
2. The prevalence of pneumoconiosis in underground coal miners was 2.84 per cent and in the surface coal workers it was 2.10 per cent.
3. About 40 per cent of the cases of pneumoconiosis in underground coal miners and 20 per cent in surface coal workers showed irregular (linear) opacities on chest X-rays.
4. The prevalence of chronic respiratory symptoms amongst the underground miners was 31.3 per cent, which was significantly higher than that amongst the surface coal workers (17.0 per cent).

5. The overall prevalence of functional abnormalities of the lungs in underground coal miners and surface coal workers was 45.4 and 42.2 per cent respectively.
6. In underground coal mines the noise levels were higher than the standards prescribed by the Director General of Mines Safety (DGMS). This can create ENT-related problems.
7. The thermal environment in the underground mines was found to be non-conducive for heavy and moderate physical work as evidenced from the Wet Bulb Globe Temperature (WBGT) index.
8. The wind velocities at the working faces in underground coal mines were found to be either low or stagnant WBGT.

In comparison to the above studies, the focus of this paper is on the financial burden of occupational health hazards. It seeks to examine the magnitude of health care expenditure amongst coal mine workers and its determinants.

The paper starts by detailing the methodology used and nature of database. This will be followed by the results of a survey undertaken in three mines in West Bengal. The prevalence and profile of diseases affecting mine workers are first described. The extent of health care expenditure is then estimated. To support the claim that health care expenditure is higher for mine workers, some statistical tests were undertaken. After presenting the statistical results, the variables that are likely to determine the burden of health care expenditure were identified. The probable nature of the relationship between these variables and health care expenditure is first stated. This is followed by tabular or graphical representations of the data. The results are finally tested using regression analysis. The policy implications of the results are presented in the concluding section.

Methodology and Database

This study is based on primary data collected directly from the mines using structured semi-closed questionnaires. The survey was carried out in the last quarter of 1999. Using the random sampling without replacement method, 15 per cent of the workforce in three mines were surveyed. All these mines were under the Pandaveswar Area Office of Eastern Coal Limited, located in the state of West Bengal. The three mines were the Pandaveswar underground mine, Khottadih open cast

mine and Khottadih underground mine. These three mines were selected to capture the possible effects of technology on the health of the workforce. Thus, for instance, the Pandaveswar mine is an underground project using the primitive method of extraction. In contrast, the Khottadih project is also underground, but it employs a fully mechanised technology. The third mine, the Khottadih open cast project, on the other hand, is an open cast mine and can be expected, a priori, to generate health hazards to a lesser extent.

There are four possible ways to estimate the burden of diseases: Disability Adjusted Life Years (DALY) (World Bank 1993). Quality Adjusted Life Years (QUALY), Willingness to Pay (WTP) (Grafni 1993) and the Swedish approach—focusing on the functioning of respondents (Nussbaum and Sen 1999). However, the application of these methods requires an extensive socio-medical infrastructure, which is not available in India. Further, the lack of previous Indian studies using the above parameters makes comparison difficult. So, a simple direct method was used—using a questionnaire to assess the suffering from any disease and the corresponding expenditure incurred for health care. This method does not estimate the seriousness of a disease, and relies exclusively on the response of the respondents. Due to this, the method employed is not as suitable to measure welfare services as compared to, say, the Swedish approach. However, it will suffice to provide data on disease episodes and the burden imposed in terms of income diverted from consumption to the treatment of such diseases.

Data was collected on the demographic composition of the family of the coal mine workers, their levels of income, education and health care expenditure incurred by them. Information was also obtained on the diseases suffered by the respondents and the members of their family.

Occupational Health Hazards and the Burden of Health Care

The number of diseases and symptoms reported by the respondents of the survey were too large to make a meaningful comparison. So the reported diseases and symptoms were clubbed and classified into similar categories to facilitate comparison. The groups are as stated below (Table 1).

Table 1
Classification of Diseases and Symptoms

Name of group	*Diseases and symptoms in group*
Lung related	Asthma, breathing problems, cold and 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 and eye problems, jaundice, neurological problems, polio, renal problems, surgical cases, thyroid, typhoid

Prevalence and Profile of Diseases

Before examining the extent of the health care burden on mine workers, it has to be established that they do face a serious health hazard. This can be done by comparing the health profile of mines studied with non-miners in the sample collected in the survey and available data for West Bengal and India (Tables 2 and 3).

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-mine workers	20.37	7.98	14.86
Mine workers	89.10	90.00	89.13

Source: All-India and state-level figures are from NCAER (Shariff 1995).

The number of diseases episodes is an important index of the health hazard facing mine workers. It can be seen from Figure 1 that this index is higher for mine workers.

The incidence of diseases amongst workers in the three mines is given in Figure 2.

A comparative study of the profile of diseases indicates that, in all three mines, lung- and pain-related diseases are the most common problems affecting mine workers. Intestinal diseases are also common

Table 3
Incidence of Diseases among Mine Workers and Non-mine Workers

	Pandaveswar underground mine			Khottadih underground mine			Khottadih open cast mine		
Groups of diseases	Mine worker	Non-mine worker	Family member of mine workers	Mine worker	Non-mine worker	Family member of mine workers	Mine worker	Non-mine worker	Family member of mine workers
Lung related	104	0	50	128	7	105	41	0	29
Pain	138	0	12	118	1	22	46	0	5
Intestinal infections	78	0	30	91	3	41	17	0	11
Tension related	45	0	10	63	4	42	15	0	7
Influenza	32	0	43	48	1	32	15	0	16
Chest pain	27	0	4	20	0	12	19	0	2
Dermatological	33	0	5	15	0	4	9	0	4
Miscellaneous	24	2	41	38	2	35	13	0	24

Source: All-India and state-level figures are from NCAER (Shariff 1995).

Figure 1
Disease Episodes

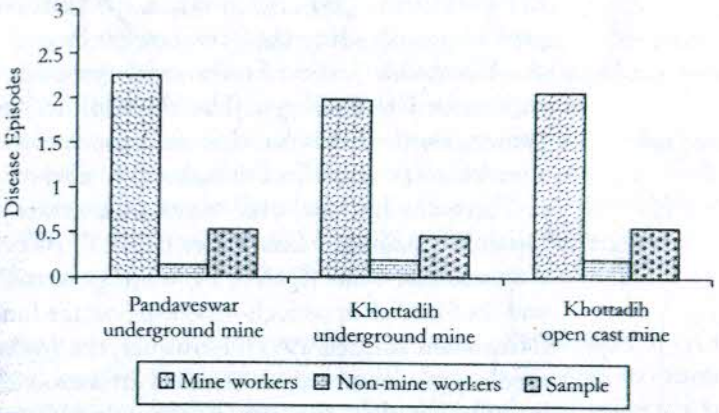
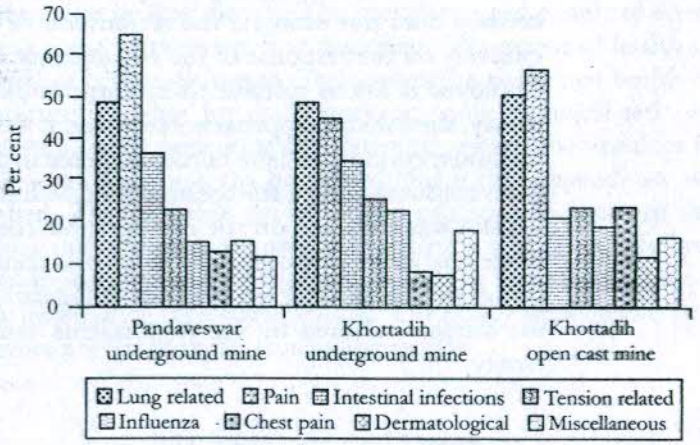


Figure 2
Incidence of Disease



amongst workers in the Pandaveswar and Khottadih underground mines.

Burden of Medical Care

Medical expenditure on each individual was compared next. This was measured using three indicators—the expenditure on health

care in absolute terms, and the expenditure on health care expressed as a percentage of family income and medical budget of the family (Table 4).

Table 4
Incidence of Diseases and Medical Expenditure

Indicators	*Pandaveswar underground mine*	
	Mine workers	*Workers in non-mine sector*
Average medical expenditure on individual (Rs.)	532.82	65.45
% of household medical budget spent on health care of individual	67.75	5.55
% of household income spent on health care of individual	2.70	0.73
	Khottadih underground mine	
Indicators	*Mine workers*	*Workers in non-mine sector*
Average medical expenditure on individual (Rs.)	516.35	128.62
% of household medical budget spent on health care of individual	59.67	7.70
% of household income spent on health care of individual	2.55	0.65
	Khottadih open cast mine	
Indicators	*Mine workers*	*Workers in non-mine sector*
Average medical expenditure on individual (Rs.)	506.35	80.96
% of household medical budget spent on health care of individual	60.94	19.19
% of household income spent on health care of individual	2.81	0.93

From the data on these variables, two facts can be observed:

1. The medical expenditure of a mine worker is correspondingly higher than that of other workers or the rest of the population on an average.
2. The percentage of medical expenditure is higher for mine workers, and this is true whether medical expenditure is expressed as a percentage of income or expenditure.

Statistical Analysis

The analysis shows that the burden of health care is much higher for mine workers. In this section this proposition is tested using statistical analysis. For this purpose the occupation of the respondent is regressed on medical expenditure (in absolute terms). The regression equation will be:

$$MEDEXP = \alpha + \beta MW$$

when MEDEXP = per capita medical expenditure; MW = 1 for mine workers and MW = 0 otherwise.

The results of the OLS estimation are given below:

Pandaveswar underground mine:

$$MEDEXP = -808.13 + 1343.61\ MW$$
$$(-41.08) \quad (28.68)$$
$$n = 1259;\ R^2 = 0.4;\ df = 1257;\ F = 822.74$$

Khottadih underground mine:

$$MEDEXP = -707.26 + 1121.46\ MW$$
$$(-32.17) \quad (20.71)$$
$$n = 1619;\ R^2 = 0.21;\ df = 1617;\ F = 429.05$$

Khottadih open cast mine:

$$MEDEXP = -707.67 + 1156.70\ MW$$
$$(-23.08) \quad (16.87)$$
$$n = 420;\ R^2 = 0.4;\ df = 418;\ F = 284.51$$

(t-ratios are given in parentheses below the coefficients)

The results of the exercise show that the value of F is significantly greater than the tabulated value in each case. This implies that the model is 'good' model and supports the central hypothesis that the medical expenditure of an individual is related to whether he is a mine worker or not. The sign of the coefficient is positive, indicating a positive relation between the two variables implying that the medical expenditure of a person will increase if he is a mine worker. The t-values of the coefficients are significantly greater than the tabulated value. The values of R^2 are reasonable (about 0.4) for the Khottadih open cast and Pandaveswar underground mines. Its value is not so

high (0.2) for the Khottadih underground mine, but is satisfactory if the fact that the data is cross-sectional in nature is considered. Alternately, medical expenditure can be taken as a percentage of income (*PERMEX*) or expenditure (*PEREXP*). The results of these equations are similar to the above set.

Pandaveswar underground mine:

$$PERMEX = 5.55 + 62.19\ MW$$
$$(9.12)\quad (42.87)$$
$$F = 1837.64;\ n = 1259;\ df = 1257;\ R^2 = 0.59$$

$$PEREXP = 0.31 + 2.38\ MW$$
$$(6.59)\quad (21.04)$$
$$F = 442.81;\ n = 1259;\ df = 1257;\ R^2 = 0.26$$

Khottadih underground mine:

$$PERMEX = 7.70 + 51.97\ MW$$
$$(11.73)\ (32.13)$$
$$F = 1032.01;\ n = 1619;\ df = 1617;\ R^2 = 0.39$$

$$PEREXP = 0.65 + 1.90\ MW$$
$$(7.31)\ (8.71)$$
$$F = 75.91;\ n = 1619;\ df = 1617;\ R^2 = 0.04$$

Khottadih open cast mine:

$$PERMEX = 8.75 + 52.18\ MW$$
$$(7.43)\ (19.81)$$
$$F = 392.56;\ n = 420;\ df = 418;\ R^2 = 0.48$$

$$PEREXP = 0.46 + 2.36\ MW$$
$$(6.45)\ (14.92)$$
$$F = 222.48;\ n = 420;\ df = 418;\ R^2 = 0.35$$

The value of F is significant in each of the six models, the signs of the coefficients are as expected and their t-values are significant. The values of R^2 are also satisfactory—except for the Khottadih underground mine when the regression of *MW* on *PEREXP* is run.

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Factors Affecting the Burden of Health Care

The following factors can be expected to determine the health of mine workers.

- level of education of the individual;
- family size;
- income of the mine worker;
- salary group to which he belongs;
- place of work;
- exposure to the mining environment; and
- technology.

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 and their costs. This creates an impetus to maintain health. In case of the mines, this variable may not be important. The reason is that a miner has to work in an environment that is unhygienic and fraught with health hazards.

Except for the second indicator in the Khottadih underground mine, the indicators do not display any clear trend with respect to educational levels (Table 5).

Family Size

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

1. It may create an insanitary domestic environment.
2. It may reduce the capability of the family to spend on the health care of the mine worker.

Most of the workers surveyed had families of five to six members. The relation between family size and health care burden is not very clear. None of the three indices—expenditure on the worker, and

Table 5
Education and Health Indicators

Indicators	Illiterate	Literate but no formal schooling	Up to Class IV	Class V–IX	Class X	Class XI–XII	Above Class XII
Pandaveswar underground mine							
Number of workers	88	51	36	26	15	4	2
Average medical expenditure	542.78	558.82	451.39	1,085.96	545.67	272.50	420.00
% of medical budget spent on worker	70.58	70.27	69.04	64.45	51.34	53.58	50.00
% of income spent on health care of worker	2.68	2.79	2.34	3.87	1.84	0.86	2.00
Khottadih underground mine							
Number of workers	80	23	52	45	38	10	19
Average medical expenditure	597.01	651.09	567.40	348.22	436.05	550.00	398.68
% of medical budget spent on worker	66.87	68.55	65.76	58.01	41.14	58.28	43.66
% of income spent on health care of worker	2.85	3.03	2.84	1.74	2.23	3.37	2.02
Khottadih open cast mine							
Number of workers	14	4	22	27	16	1	0
Average medical expenditure	442.86	677.50	558.64	502.70	450.00	740.00	0
% of medical budget spent on worker	62.62	63.60	60.00	68.77	47.10	59.68	0
% of income spent on health care of worker	2.64	3.67	3.18	2.86	2.97	2.90	0

proportion of income and medical budget spent on worker—indicates any trend (Table 6).

Table 6
Members in a Family and the Indicators of Health

Mine	Family size	Number of mine workers	Average medical expenditure on mine worker	% of medical budget spent on mine worker	% of income spent on health care of mine workers
Pandaveswar underground	1–4	37	725.27	67.26	2.54
	5–6	122	880.86	70.80	2.73
	7–8	48	838.13	64.16	2.38
	9 & above	15	2,234.00	55.57	3.79
Khottadih underground	1–4	61	1,013.74	66.35	2.49
	5–6	102	1,083.87	55.41	2.71
	7–8	77	1,278.18	63.46	2.40
	9 & above	27	1,575.56	49.86	2.47
Khottadih open cast	1–4	35	807.86	69.41	3.01
	5–6	33	917.06	57.14	2.79
	7–8	14	1,022.14	56.14	2.71
	9 & above	2	707.50	8.97	0.47

Income

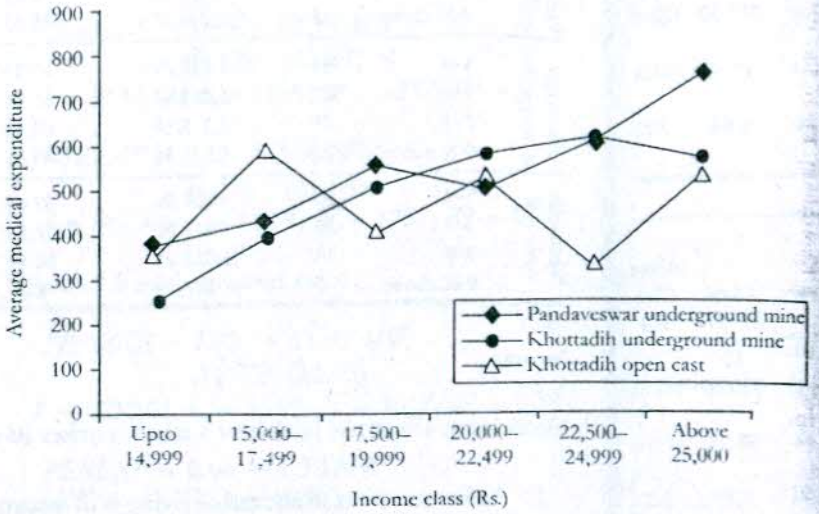
Income can affect the health of a mine worker in several ways:

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 work 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 worker with a higher pay is more likely to be in higher 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 though a highly paid worker is occupied in an activity that may involve no physical strain, he is under mental stress due to the heavy responsibilities of his position. This is particularly true for managerial posts. This may counterbalance the above forces.

From Figure 3 it is clear that the health care expenditure of mine workers displays a rising trend in the Pandaveswar and Khottadih underground mines. In the case of the Khottadih open cast mine, however, the data does reveal any clear trend.

Figure 3
Trend of Average Medical Expenditure



The percentage of income spent on medical expenditure of a worker can be expected to rise with income in initial stages. This is because of Engel's Law. Workers in the lower income groups suffer from health problems, but a significant portion of their income is allocated to food and shelter. As income increases, they can purchase 'better health'. After income crosses a certain level, however, the health profile may improve as working conditions are more hygienic. From this point onwards, the percentage of income spent on health care of the worker will fall.

Such a trend is observable for the Khottadih underground and open cast mines; in Pandaveswar, though, the percentage of income spent on health care expenditure of the worker decreases with income (Figure 4).

Income Elasticity of Health Care Before proceeding to the next determinant of health care cost, the concept of income elasticity of health

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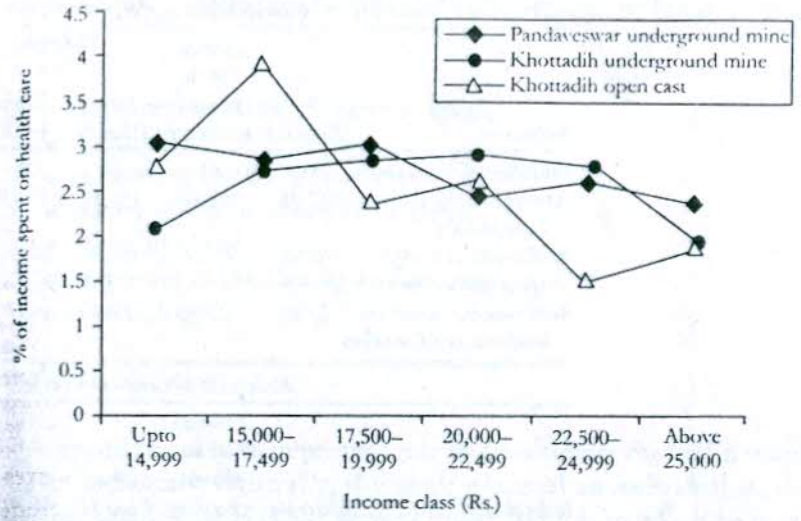
Figure 4
Expenditure on Health Care



care expenditure is introduced. This can be defined as the degree of responsiveness in expenditure on the health care of an individual due to a change in income. Mathematically, elasticity (E) can be written as:

E = % change in health care expenditure / % change in income

Given that the prevalence of the disease is more among mine workers, one can expect that $E_{mw} > E_{nmw}$, when E_{mw} is elastically of health care of a mine worker, and E_{nmw} is the elasticity of a non-mine worker. To estimate elasticity, the following function is considered:

$$Y_i = a\,(Mex_i)^b \qquad \text{(i)}$$

When Y = family income;
Mex = medical expenditure of individual i;
and a and b are constants

Taking log of equation (i),

$$\log Y_i = \log a + b \log Mex_i \qquad \text{(ii)}$$

It is easy to see that

$$\mathrm{d}(\log Y_i) / \mathrm{d}(Mex_i) = b = E_i \qquad \text{(iii)}$$

Estimating equation (ii) for non-mine workers and mine workers separately, the results are presented in Table 7.

Table 7
Elasticities of Mine and Non-Mine Workers

	Elasticity	
Mine	*Mine workers*	*Non-mine workers*
Pandaveswar underground	-0.3717	-0.4048
Khottadih underground	1.5885	0.0795
Khottadih open cast	0.2756	0.2453
Pooled data	0.5764	-0.1538

From the table it is clear that income elasticity of health care cost is higher for the mine worker than the non-mine worker for the three different mines under study and also for pooled data. This is because of the dependence of the family of the mine worker.

Now the signs of the elasticities are positive except in the Pandaveswar mine. This implies that as income is rising, health care expenditure is also increasing, indicating that Engel's Law is not operative. In Pandaveswar, however, elasticity is negative, indicating a negative relation between health care expenditure and income. In this case, therefore, Engel's Law can be observed.

Salary Group

Another important determinant of the health burden on the worker is the nature of duties. There are about 50 different jobs in the mining industry. One way to categorise them is by salary. 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. It can be expected that the health profile of these workers will be the best.
2. Piece rate workers: These workers include loaders and trammers who are paid according to the quantity of coal handled by them. These workers are exposed most to the health hazards of coal mines.

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3. Time rate workers: The remaining workers are classified as time rate workers. They are paid according to the number of days they work in a month.

The data does not indicate any clear trend between salary groups and health care burden (Table 8). In all the three mines the burden is least for the time rate workers. But it is quite possible that this is simply because of the low average income of this group. The income of time rate workers is the lowest amongst the three groups (for Pandaveswar and Khottadih underground mines). This may imply that workers are unable to divert income from subsistence purposes to health care.

Table 8
Salary Group and Health Indicators

Mine	*Salary group*	*Workers*	*Average medical expenditure on mine worker*	*% of medical budget spent on mine worker*
Pandaveswar underground	Monthly rate	30	1,022.83	61.81
	Piece rate	111	532.52	73.18
	Time rate	83	512.29	63.40
Khottadih underground	Monthly rate	37	559.09	57.39
	Piece rate	27	714.07	68.78
	Time rate	207	482.29	58.84
Khottadih open cast	Monthly rate	14	532.14	52.94
	Piece rate	7	489.29	75.92
	Time rate	63	505.37	61.07

Place of Work

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. This first group of 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. In their case, activities cannot be divided into underground and surface activities. A different method of categorisation has to be adopted here. In such mines the production process is extremely machine intensive. This implies that part of the worker force has to be occupied with servicing and maintaining machines and equipment. In addition, there is a group of workers who are involved in extraction of the coal operating the machines. Finally, there is a third group consisting of office workers (Table 9).

Table 9
Health Indicators for Workers Categorised by Place of Work

Mine	*Place of work*	*Number of mine workers*	*Average medical expenditure on mine worker*	*% of income spent on health care of mine worker*	*% of medical budget spent on mine worker*
Pandaveswar underground	Underground	142	850.07	2.53	70.54
	Surface	78	1,083.72	3.03	63.82
	Office	2	1,400.00	1.39	22.32
Khottadih underground	Underground	162	1,217.98	2.60	58.94
	Surface	97	1,100.15	2.49	61.84
	Office	8	1,165.63	2.29	48.20
Khottadih open cast	Mining activity	69	900.84	2.81	59.86
	Service maintenance	12	752.92	3.10	69.81
	Other	3	1,023.33	1.78	50.09

Exposure to Mining Environment

Another factor that can be expected to affect the 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 used as a proxy for exposure.

A close relationship between exposure to the mining environment and health care burden is established if the indicators of health care burden used in the analysis are considered (Table 10).

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Table 10
Experience and Health Indicators

Pandaveswar underground mine	*Less than 5 years*	*5–14 years*	*15–24 years*	*25–35 years*
Disease	1.5	2.7	2.8	2.9
Total expenditure	219.64	409.58	531.17	728.04
PERMEX	46.79	64.07	66.22	70.94
PEREXP	1.41	2.47	2.64	2.94
Khottadih underground mine	*Less than 5 years*	*5–14 years*	*15–24 years*	*25–35 years*
Disease	1.5	1.9	2.5	3.1
Total expenditure	261.79	408.08	533.29	700.12
PERMEX	44.53	51.28	65.12	67.09
PEREXP	1.49	2.28	2.56	3.16
Khottadih open cast mine	*Less than 5 years*	*5–14 years*	*15–24 years*	*25–35 years*
Disease	1.0	2.7	2.5	2.5
Total expenditure	180.00	485.33	529.21	523.00
PERMEX	20.93	63.26	66.58	51.80
PEREXP	1.50	3.24	2.77	2.23

Technology and the Health Care Burden

In the three mines surveyed, three different technologies are used. Pandaveswar and one of the Khottadih mines are underground mines, while the other Khottadih mine is an open cast mine. Technological differences may lead to inter-mine variations in health care expenses.

The technology in the Khottadih open cast mine is much more mechanised in nature. Further, the work occurs in the open air under the sky. These may create dispersed environmental hazards, but less local health hazards. On the other hand, Pandaveswar and Khottadih underground mines are basically labour intensive and less dependent on heavy machine power, extracting coal from the underground tunnel in a much more congested atmosphere. Thus, health hazards are more likely in these underground mines than in the mechanised open cast technology. Again, among the underground mines, the Khottadih mine is more machine intensive in nature and therefore it can be expected that prevalence of health hazards are less than in Pandaveswar.

To test the proposition that technology plays an important part in determining the state of health of the workers, a regression is run on pooled data. Two dummies are taken—*PDV* (=1 for respondents

working in the Pandaveswar 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. The regression results are:

$$TOTAL\_EX = 506.35 + 10.00\ KUG + 26.47\ PDV$$
$$(12.43)\quad (0.55)\quad (0.21)$$
$$F = 0.20;\ R^2 = 0.000689;\ n = 573;\ df = 570$$

$$PERMEX = 60.94 - 1.27\ KUG + 6.81\ PDV$$
$$(16.92)\quad (-0.31)\quad (1.61)$$
$$F = 3.82;\ R^2 = .013223;\ n = 573;\ df = 570.$$

The regression result for *TOTAL_EX* indicates the absence of any effect of technological variations on the health care expenditure of the respondent F is not statistically significant, nor is the individual t's significant. In comparison, *PERMEX* appears to be sensitive to technological variations. The share of the worker in the medical budget of the family is higher in Pandaveswar compared to that in the Khottadih underground mines. However, the difference in this figure between the two Khottadih mines is not significant.

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, the Pandaveswar mine uses a primitive labour-intensive technology, while both the Khottadih projects are much more mechanised. So the three mines are clubbed into two groups as follows, based on a new variable,

INTENSITY

INTENSITY = 0 for the Khottadih projects
= 1 for the Pandaveswar project

It is expected the incidence of the diseases (*DIS*) will be positively related to *INTENSITY*.

The results are as follows:

$$DIS = 2.40075 + 0.282257\ INTENSITY$$
$$(28.2074)\quad (2.42351)$$
$$n = 573;\ df = 571;\ F = 5.87;\ R^2 = .010181$$

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This model yields a better result than the earlier model. The sign of *INTENSITY* is as expected; its t-value is high; the value of F and R^2 are also quite high; the Akaike information criterion is minimised in the second model. Therefore, it can be argued that the extent of mechanisation is a significant factor affecting health hazards in the coal mining industry. If it is a labour-intensive underground mine then the occurrence of the health hazards will be high.

The Statistical Model

In this section some more rigorous tests will be applied to determine the relation between the health care burden and the determinants of this burden identified earlier. Like the preceding analysis, regression analysis will be used to test which of the seven factors stated earlier affect the health care burden of the workers significantly, and what is the direction of causality.

Two regression equations—one with *TOTAL_EXP* as the dependent variable and the other with *PERMEX* as the dependent variable—are estimated. The regressors are:

EDU = Dummy for educational levels
TM = Family size
IT = Family Income in Rs
EXTRACT = 1 for workers engaged in extraction process
= 0 otherwise
MOTH = 1 for monthly workers
= 0 otherwise
EXP = Experience coal mining industry (in years)
PDV = 1 for respondents from Pandaveswar
= 0 otherwise

From Table 11, it can be seen that the value of F is statistically significant. Only five of the variables, however, are significantly related to *TOTAL_EXP*. The inverse relation between family size and health care possibly arises from an insurance motive. Large families are dependent upon the sole bread earner. Hence, they seek to minimise the risk of income loss (due to ill health) by spending on the mine worker. This expenditure is a sort of premium payment on the part of the family.

Table 11
Determinants of Total Expenditure (*TOTAL_EXP*)

Variable	*Coefficient*	*t-ratio*
Constant	342.1352691	3.296
TM	−11.75603025	−1.393
EDU	−19.36053111	−1.723
IT	0.3035602598E-02	1.234
EXTRACT	21.93470478	0.288
MONTH	36.28462677	0.667
EXP	12.23135845	6.129
PDV	−44.66657762	−1.383

Note: n = 573; Deg. Fr. = 565, F = 9.68; R^2 = 0.107; Adjusted R^2 = 0.096.

The signs of experience and education are as expected and are also statistically significant. In comparison, the signs for *PDV* and income are not expected. Income is positively related to health care costs. This can be due to three reasons. First, income may be high not only because of the higher post held by the respondent, but also because of his length of service. In case of the latter, his long exposure to the mining environment will have a toll on his health and call for greater health care expenditure. At the same time, higher income may increase the opportunity cost of illness due to absenteeism and nature of responsibilities. In such cases the respondent may choose to invest more in health care as a preventive measure. Third, higher income provides the respondent with the flexibility to take into account such considerations.

The signs of *EXTRACT* and *MONTH* are not statistically significant. One reason is that *EXTRACT* is rather an arbitrary classification to lump workers from underground and open cast mines. In case of *MONTH* the reason may be due to the small size of monthly rate workers as opposed to the large size of the residual sample.

Another possible indicator of health care is *PERMEX*. The regression equation for this dependent variable is estimated to yield the results shown in Table 12.

Regression results (Table 12) based on the earlier model show that the value of F is statistically significant. The coefficients of *TM*, *IT* and *EDU* are all significant and negative. While the signs are as hypothesised for *EDU* and *IT*, it is unexpectedly negative for family size. This can be explained in terms of the insurance motive explained earlier. The

coefficients of *PDV* and *EXP* are significant and positive. These signs are as expected.

Table 12
Determinants of Medical Expenditure as a Percentage of Income (*PERMEX*)

Variable	*Coefficient*	*t-ratios*
Constant	76.98958994	8.286
TM	−2.312265464	−3.062
EDU	−3.323820706	−3.305
IT	−0.3499193955E-03	−1.589
EXTRACT	0.9318324031	0.137
MONTH	1.721294788	0.354
EXP	0.7537862481	4.220
PDV	3.190133264	1.104

Note: n = 573; Deg. Fr. = 565; R^2 = 0.096198; F = 8.59.

Finally, the results of regressions run for individual mines are briefly stated in Table 13. This helps to identify the specific determinants of health care costs in each of the mines.

Table 13
Determinants of Health Care Costs in Each Mine

	Pandaveswar underground mine		*Khottadih underground mine*		*Khottadih open cast mine*	
Variable	*TOTAL_EXP*	*PERMEX*	*TOTAL_EXP*	*PERMEX*	*TOTAL_EXP*	*PERMEX*
EDU	−20.14	−3.48	–	−2.49	–	−3.04
IT	0.47	−0.35	0.44	−0.61	−0.007	–
TM	−17.89	−1.37	–	–	−30.49	−7.48
MONTH	–	–	–	–	–	−9.89
EXP	11.58	0.64	16.14	0.96	10.22	0.63
MINING	–	–	–	–	–	–
UNDER-GROUND	–	9.45	–	–	–	–
R^2	0.16	0.09	0.12	0.09	0.05	0.17
F	10.13	4.13	17.49	9.21	1.43	3.91
n	222	222	267	267	84	84

Note: The results for only variables whose coefficients are significant are reported.

Table 13 shows that experience of the worker is the most important determinant of health care costs in the three mines. In addition, education, family size and family income are also important factors.

Conclusion

The analysis has established three facts. First, mining does pose significant health hazards on mine workers. Second, this health hazard increases with exposure to the mining environment, it also depends upon socio-economic parameters like income, family size and educational standards of the respondent. Finally, the nature of the technology used in the extraction of coal is an important determinant of the health hazards. The episodes of diseases increase when the technology becomes more labour intensive.

The results indicate certain policy measures to tackle this problem. In the short run, it is necessary to extend improved medical facilities at subsidised rates to mine workers. In view of the paucity of funds, workers with long periods of exposure to the mining environment and those working underground can be targeted. Similarly, certain types of diseases, as identified earlier, are common. Medical facilities should provide especial treatment for these diseases. In the long run, however, a shift to less hazardous technologies is desirable. At the same time, socio-economic changes like increasing income and educational standards can play a preventive role.

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