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Prevalence of Occupational Lung Disease in a Random Sample of Former Mineworkers, Libode District, Eastern Cape Province, South Africa

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Background *Gold mineworkers in South Africa are exposed to high levels of silica dust as a result of which they are at risk of developing silicosis, which is a compensable disease. The incidence of tuberculosis is also high.*

Methods *To determine the prevalence of occupational lung disease and the previous compensation history in former migrant mineworkers, a study was undertaken in a random sample of men living in Libode, a rural district of Eastern Cape Province, South Africa. Two hundred thirty-eight ex-mineworkers were examined according to a protocol that included chest radiography and spirometry. Chest radiographs were read into the International Labour Organisation (ILO) classification for pneumoconioses by two readers.*

Results *The mean age was 52.8 years, and the mean length of service was 12.15 years. The prevalence of pneumoconiosis (≥ILO 1/0) was 22% and 36% (variation by reader). For both readers, a significant association between length of service and pneumoconiosis and between pneumoconiosis and reduction in FVC and FEV was found. Twenty-four percent of study subjects were eligible for compensation.*

Conclusion *There is a high prevalence of previously undiagnosed, uncompensated pneumoconiosis in the study group. As a result of the failure to diagnose and compensate occupational lung disease, the social and economic burden of such disease is being borne by individuals, households, and the migrant labor-sending communities as a whole.* Am. J. Ind. Med. 34:305–313, 1998. *© 1998 Wiley-Liss, Inc.*

KEY WORDS: mineworkers; migrant; epidemiology; community based; latent period; pneumoconiosis; tuberculosis; compensation

INTRODUCTION

This study was conducted in March 1996 to evaluate the prevalence of occupational lung disease in particular, pneumoconioses, tuberculosis, and obstructive airways disease, in a random sample of former mineworkers in the Libode magisterial district of the Eastern Cape Province, South Africa. The extent to which workers had been previously compensated under the Occupational Diseases in Mine Workers Act (ODMWA) and the functioning of the compensation system were also of interest. The objectives of the study were threefold. The first objective was to ascertain the prevalence of occupational lung disease in a random sample of ex-mineworkers. The second objective was to ascertain whether any of the study subjects might be eligible for compensation and if so to assist them to submit and process claims. The third objective was to attempt to relate mining history to radiological evidence of pneumoconiosis, tuberculosis, emphysema, lung function performance and reported respiratory disease symptoms.

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Gold was discovered on the Witwatersrand in 1886, and for over a century, oscillating migrant labor has been a central feature of employment for black gold mineworkers. By 1910, there were approximately 200,000 black migrant gold mineworkers in South Africa; by 1940, the number had risen to approximately 300,000; and by 1985, there were approximately 500,000 [Moodie, 1994]. Since then, the industry has retrenched, and by 1996, this figure had dropped to 340,000 [Minerals Bureau, 1997]. Historically, migrant mineworkers have come to South Africa from as far north as Angola and Tanzania. This system of oscillating labor migration leads to the geographic separation of home and work and the movement of workers, without their families, between rural and urban areas [Callinicos, 1980]. Even now, migrant labor remains the dominant form of labor supply to the mines and more than 90% of those currently employed are migrants from rural districts within South Africa or from neighboring states [Steen et al., 1997]. Gold mineworkers have historically been recruited through The Employment Bureau of Africa (TEBA), and their database provides a comprehensive record of mine labor recruitment in southern Africa.

The migrant labor system in southern Africa has led to uneven economic development, which promotes the strength of the core urban economy and hinders development at the periphery [Wolpe, 1972]. Although mining initiated industrial development and urban growth, rural labor-sending areas have become, in effect, dislocated urban communities, with eroded subsistence economies dependent on mine wages [Mayer, 1980; Wilson, 1985].

The Eastern Cape Province, specifically the eastern part of the Eastern Cape (known as the Transkei) has been a major labor-sending area for the South African mining industry for over a century [Wilson, 1972]. Between 1980 and 1990, 30% of workers employed in those South African mines affiliated to the Chamber of Mines (COM) were labor migrants from the Eastern Cape [Chamber of Mines, 1993]. Data supplied by TEBA indicate that, by April 1997, this figure had dropped to 17% of the total workforce when 84,672 men [personal communication, Ms W. Cramer, TEBA, 1997] recruited from the Eastern Cape, were in mine service down from a peak of 133,965 in 1986 [Crush, 1995].

Gold mining entails exposure to dust with a high content of free crystalline silica. The respiratory diseases associated with gold mining are simple chronic bronchitis [Sluis-Cremer et al., 1967], emphysema [Becklake et al., 1987], chronic airways obstruction [Wiles and Faure, 1977], silicosis [Beadle, 1977], and tuberculosis [Kleinschmidt and Churchyard, 1997]. These diseases generally have a long latency period between exposure to risk factors on the mines and the development of disease; as a result, mineworkers often manifest occupational lung diseases in the areas to which they return after leaving mine employment, rather than while at the mine itself.

South Africa can draw on over 6 decades of research on mining-related occupational lung disease. However, this research has concentrated mainly on in-service workers with a strong bias toward disease in white workers. Although labor migrancy and its impact on rural communities in Southern Africa has attracted research interest from economists, sociologists, and anthropologists, very little research has been done into the health status of ex-mineworkers. The little available research suggests that the burden of occupational lung disease in labor-sending communities is considerable, and a recent prevalence study of former mineworkers resident in the Kweneng district of Botswana found an overall prevalence of pneumoconiosis (≥1/0, ILO) of 26 to 31% [Steen et al., 1997]. In light of the recent large scale retrenchments in the gold mining sector [Crush, 1995] and the consequent return of workers to rural communities, with limited occupational health provision, studies of the health status of former mineworkers are especially important.

MATERIALS AND METHODS

The Libode magisterial district was selected for the study because it is a typical Eastern Cape mine labor-sending area, with a long history of labor recruitment. The area also has a functioning TEBA office and complete records of recruitment for the district are available for the period 1969–1980. The recruitment records do not exclude men who had previously been recruited before 1969. These recruitment records provided the sampling frame for the study.

Libode village, which is at the centre of the magisterial district is situated roughly 25 kilometers northeast of Umtata, the major business center for the region. In the following text, Libode refers to the magisterial district. The latest available census data for the Libode district indicate that in 1991 the population was 119,202, of whom 1.2% were defined as living in an urban area. Libode has no hospital, and the people from the district use St. Barnabas Hospital in the neighboring district of Ngqeleni. A survey carried out in 1994 found that 97.5% of households had no access to sanitation facilities and that 60% used rivers and streams for their water supply [National Electrification Forum, 1994].

The study population consisted of all 11,706 adult male Libode residents recruited by TEBA between 1969 and 1980. The time frame was chosen to ensure that sufficient time had elapsed for diseases with a long latent period to become manifest. To detect a prevalence of 10% ± 3% (95% confidence limits) requires a sample size of 400. To allow for the possibility that some mineworkers might be dead, missing, or still working, the random sample size was increased to 800. The sample was chosen from the study population by numbering all the records and generating random numbers to define the sample.

Tracing Method

TEBA recruitment records list information pertaining to the settlement, headman, and chief of each recruited man, which serves as a rural address. Community leaders, both traditional and civic, were enlisted to trace the ex-workers in the random sample. The random sample was sorted by settlement, and a list of names for each settlement was handed to the leadership representatives of that settlement for tracing purposes. Community meetings were held in each of the 25 settlements within Libode district. At each meeting of civic and traditional leadership structures, a representative of the National Union of Mineworkers (NUM) and an employee of TEBA confirmed that men listed on the random sample were alerted and could attend. At these meetings, the aims and objectives of the study were explained to the communities involved. Subsequent to these meetings, informed written consent was obtained from those who were to participate in the random sample survey. The consent form was written in Xhosa, the first language of the study subjects. The few study subjects who did not attend the community meetings were sought out and given an explanation of the aims and objectives of the study, after which they were asked to sign a consent form. Ethical approval was obtained for the study by the Ethics Committee for Research on Human Subjects, University of the Witwatersrand, South Africa.

All data were coded using Microsoft Excel for subsequent statistical analysis using Epi Info and STATISTICA. Data were cross-checked to detect and correct coding errors.

Medical Examinations

The study subjects all underwent spirometry, radiography, and a general medical examination. This examination took place at St. Barnabas Hospital. A mining occupational history was taken for each individual by a trained fieldworker, who is himself an ex-mineworker resident in Libode. The information supplied in the work history was later corroborated from TEBA records.

Each person had a full-size posteroanterior 125 kV chest radiograph, which was carried out by the radiographer from St. Barnabas Hospital in accordance with International Labour Organisation (ILO) specifications [International Labour Organisation, 1981]. The chest radiographs of the random sample were read into the ILO classification of the pneumoconioses by two readers: one an experienced registered pulmonologist and occupational medicine practitioner and the other an experienced registered radiologist. X-rays were read in a blinded, independent fashion. Readings and subsequent analysis are not based on averaged data but rather are presented separately. Spirometric tests that included FVC and FEV_1 were performed while the subjects were seated and wearing a nose clip. Bacterial/viral filter mouth pieces were used. All tests were undertaken by a trained technologist using a Vitalograph compact spirometer (Buckinghamshire, U.K.), which was calibrated according to American Thoracic Society criteria. Respiratory function tests were carried out according to American Thoracic Society guidelines [American Thoracic Society, 1994]. Full detailed instructions were given in Xhosa, the home language of the participants. Subjects were required to perform three acceptable curves, the best of which was selected. In only 8.3% did the two best curves differ by more than 5%, and these cases were excluded from further analysis. Given the exclusion of this group, the results are likely to be conservative in relation to the extent of the disease [Eisen et al., 1987]. The height, weight, age, gender, and race of each study subject was recorded.

Medical benefit forms for the purpose of applying for workers' compensation were completed for all study subjects and, together with the chest radiographs and spirometry results, these were forwarded to the compensation authorities.

RESULTS

Of the 800 men in the original random sample, 446 (56%) were found to be dead and 116 (15%) were still involved in migrant work and, hence, were unavailable for examination. The remaining 238 (30%) were available for examination. The average height of the men was 166 $\pm$ 12 cm (here and elsewhere $\pm$ indicates standard deviations). The average weight was 60 $\pm$ 14 kg. The mean age of the random sample group was 53 $\pm$ 10 years (range, 34–78 years). The mean years of mine service which could be confirmed using TEBA records was 9.3 $\pm$ 7.2 years. In addition to confirmed service, some of the reported service could not be confirmed. The mean total service (confirmed and unconfirmed) was 12 $\pm$ 7 years (range, 6 mo – 34 years in both cases). Of the unconfirmed service, 30% was reported by the workers to have been at mines for which TEBA does not recruit. The mean date of first exposure was 1964 $\pm$ 9 years, (range, 1940–1980) giving a mean time since first exposure of 32 years. The mean year of last exposure was 1984 $\pm$ 8 years (range, 1957–1995). Analyzing the data using confirmed service only did not significantly alter any of the findings. Where service could be confirmed, it was in good agreement with the self-reported service, giving us confidence in the small proportion of service that could not be confirmed.

Based on cumulative service, working as a driller accounted for 38% of confirmed service, followed by 13% as team leaders, 12% as stope team workers, 10% as winch drivers, 8% as locomotive drivers, 2% as lashers, and 2% as spanner men. All other service cumulatively amounted to 15% within which no job category individually amounted to more than 3%. For the analysis that follows, total service (confirmed and unconfirmed) has been used, because this gives the most accurate representation of exposure. The overwhelming majority of the mine service of the study group was undertaken in jobs involving high dust exposure; therefore, it was not possible to determine the relative risk for different job categories. Kleinschmidt and Churchyard [1997] have recently published a retrospective cohort study of the variation in tuberculosis incidence rates in subgroups of South African gold mineworkers with 55,822 person years of follow-up in which they were able to establish relative risk for tuberculosis in relation to age, time period, cumulative length of service, and occupational category.

TABLE I. International Labor Organisation Film Grade Quality as Read by Readers 1 and 2, for Radiographs of a Random Sample of Ex-mineworkers, Libode District, 1996[a]

Film grade quality	Reader 1 (%) N = 238	Reader 2 (%) N = 238
1	66	69
2	23	22
3	8	6
4	3	3

[a]1 = good, 2 = acceptable, 3 = poor but still acceptable, 4 = unacceptable. N = sample size.

Radiological Readings

Table I gives the film grade quality as determined by the two readers, and in both instances only 3% were regarded as unreadable. The ILO 10-point scale for profusions of small opacities was used to classify the X-rays. Pneumoconiosis was defined as ILO profusions of $\geq$1/0. The overall prevalence of small opacity profusions are given in Table II. There was a good correlation between the two sets of readings (P = 0.71), although reader 2 placed significantly more people into category 0/0 and significantly fewer people into categories 0/1, 1/0, and 2/1 than did reader 1. The Kappa statistic for the data in Table III is 0.49, which compares favorably with the values found in a study of interobserver variation in classifying chest radiographs for pneumoconiosis [Musch, 1984].

As shown in Table III, reader 1 found a higher prevalence of small opacity profusions (36% $\geq$ 1/0) than did reader 2 (22% $\geq$ 1/0). Both sets of readings establish a high prevalence of pneumoconiosis in this sample. Although there was a good correlation between the readers, there was a significant difference between the two sets of readings (χ^2 test, $p < 0.01$). Reader 1 classified radiological tuberculosis as present in 33% of cases compared with 47% for reader 2. The difference between the two readers was statistically significant ($p < 0.05$). For men who were classified as having radiological evidence of tuberculosis, reader 1 found a significantly greater proportion of pneumoconiosis than did reader 2 (45% compared with 12%).When the cases with radiological tuberculosis are excluded, the proportion of cases diagnosed as having pneumoconiosis does not differ significantly between the two readers, the proportions being 31% and 29% ($p > 0.1$). The difference between the diagnosis of pneumoconiosis by the two readers when tuberculosis is present highlights an important issue concerning the ILO system of classification. Reader 1 coded any changes he felt were consistent with pneumoconiosis whether or not tuberculosis was present. Reader 2 was more cautious about coding for pneumoconiosis in the presence of tuberculosis. Reader 1 classified 10% prevalence of radiological evidence of emphysema compared with 7% for reader 2. The difference between the two readers was not significant ($p >$ 0.05).

Univariate Analyses

Because pneumoconiosis and tuberculosis can both have long latent periods, age and length of service are likely to be associated with these diseases. To explore this, we first carried out a univariate analysis in which the radiologic evidence for pneumoconiosis, tuberculosis and emphysema for each reader was tested for association with age and total length of service. None of the ratios of the variances differed significantly from 1 (F test of significance). The means were then compared using *t* tests for the difference between the means and Kolmogorov-Smirnov tests for the difference in the overall distributions. It should be noted that there was no association between smoking (treated as a categorical variable) and age or total length of service ($p > 0.05$). Men with pneumoconiosis served about 3 years longer than those without pneumoconiosis, but there was no significant association between total length of service and smoking, radiologic evidence of tuberculosis, or emphysema. Men with pneumoconiosis are about 7 years older than those without pneumoconiosis, whereas men with tuberculosis are about 4 years older than those without tuberculosis. Men with radiological evidence of emphysema are about 7 years older than men without radiological evidence emphysema according to reader 1; for reader 2, the difference is not significant.

Multivariate Analyses

Radiology

Because both age and length of service are significantly associated with pneumoconiosis and tuberculosis, a multivariate analysis was then carried out to determine if either one was sufficient, or if both were needed, to predict the probability of developing of disease. The relationship be-

TABLE II. Number of Random Sample Study Subjects, Diagnosed from Radiographs, in Each International Labor Organisation Category as Read by the Two Readers, Libode District, 1996

	Reader 1										
Reader 2	0/0	0/1	1/0	1/1	1/2	2/1	2/2	2/3	3/2	3/3	Total
0/0	127	13	17	8	0	7	2	0	0	1	175
0/1	1	0	0	1	0	0	0	0	0	0	2
1/0	0	0	2	1	1	0	0	0	0	0	4
1/1	4	0	2	8	2	1	2	0	0	0	19
1/2	0	0	1	1	0	0	1	0	0	0	3
2/1	0	0	1	0	0	2	0	0	1	0	4
2/2	0	0	0	3	0	3	8	0	0	0	14
2/3	0	0	0	0	0	0	1	0	0	0	1
3/2	0	0	0	0	0	0	0	0	0	0	0
3/3	0	0	0	0	0	0	3	3	0	0	6
Total	132	13	23	22	3	13	17	3	1	1	228

TABLE III. Number of Random Sample Ex-mineworker Study Subjects in Each Primary International Labour Organisation Category by Reader, Libode District 1996[a]

ILO category	0/0–0/1	1/0–1/2	2/1–2/3	3/2–3/3
Reader 1	145 (64%)	48 (21%)	33 (14%)	2 (1%)
Reader 2	177 (78%)	26 (11%)	19 (8%)	6 (3%)

[a]Percentages of the total number read by each reader.

tween pneumoconiosis, age, and length of service was examined with a logistic regression of pneumoconiosis against age and length of service using the individual data points and a maximal likelihood fit.

Age and total length of service both give good fits to the data ($p < 0.05$), but adding age to length of service or vice versa does not improve the fit significantly ($p > 0.1$), and none of the other variables in the data set give a significant improvement. Because it is known that pneumoconiosis is caused by exposure to dust, it is reasonable to assume that the explanatory variable is total length of service.

Spirometry

Spirometric results were compared against the radiological results of reader 1. To explore the factors that affect lung function, we have considered two measures: FVC and FEV_1, each in relation to smoking status, radiologic tuberculosis diagnosis, radiologic pneumoconiosis diagnosis, radiologic emphysema diagnosis, age, weight, height, and length of service, and the possible interactions by using analysis of covariance. The significant effects for FEV_1 and FVC are given in Table IV.

Because the average age is close to 50 years, the average weight is close to 60 kg and the average height is close to 170 cm, we have standardized the data to a person of this age, weight, and height. The model for the lung function measurements is then:

$$\mathrm{x} = \mathrm{c} + \mathrm{a} \times (\mathrm{age} - 50) + \mathrm{w} \times (\mathrm{weight} - 60) + \mathrm{h} \times (\mathrm{height} - 170) + \mathrm{s} + \mathrm{t} + \mathrm{e}$$

where *x* (where x is either FVC or FEV_1) and *c, a, e, w, h* are the values in the Table and *s, t,* and *e* take the values in the Table if the relevant disease is present and take the values 0 if it is absent. The expected values of FEV_1 and FVC are then 2.8 and 3.7 liters for a person of the standard age, weight and height having none of the diseases.

Compared with a healthy person of standard age, weight, and height, FEV_1 and FVC decline by 1% and 0.7%, respectively, for each year of age, increase by 0.4% and 0.2%, respectively, for each additional kilogram of weight, and increase by 0.7% and 0.8%, respectively, for each centimeter of height. Pneumoconiosis reduces FEV_1 and FVC by 10.3% and 8.8%, respectively, tuberculosis by 9.5% and 9%, respectively, whereas radiologic evidence of emphysema reduces FEV_1 by about 19.2% and FVC by 11.3 %.

A convenient and much used measure of lung function is the ratio of FEV_1 to FVC. Figure 1 shows a histogram of the distribution of this for healthy persons (those without any radiological evidence of these three diseases) and sick persons (those with radiological evidence of one or more of these diseases). From the histogram in Figure 1, everyone with FEV_1/FVC of less than 0.7 has radiological evidence of either tuberculosis, pneumoconiosis, emphysema, or some

TABLE IV. Analysis of Covariance, for Random Sample Study Subjects as Described in the Text, for FEV_1 and FVC Against Age, Weight, and Height (Covariates), Smoking and Pneumoconiosis, and Tuberculosis and Emphysema Diagnosis (Factors)[a]

	FEV_1			FVC		
Parameter	Coefficient	Standard error	*P*	Coefficient	Standard error	*P*
Constant, *c*	2.8049	0.0424	***	3.6811	0.0395	***
Age, *a*	−0.0283	0.0041	***	−0.0263	0.0045	***
Weight, *w*	0.0102	0.0047	*	0.0090	0.0052	ns
Height, *h*	0.0210	0.0076	**	0.0308	0.0083	***
Silicosis, *s*	−0.2901	0.0866	***	−0.3227	0.0939	***
Tuberculosis, *t*	−0.2678	0.0910	**	−0.3315	0.0979	***
Emphysema, *e*	−0.5396	0.1458	***	−0.4146	0.1568	**

[a]Neither total length of service, smoking, nor any of the interactions are significant. Age is measured in years, weight in kilograms, and height in centimeters. For FEV_1, $R^2 = 51\%$. $F_{6,179} = 33.5$ ($p < 0.00001$). Standard error of estimate = 0.54. For FVC, $R^2 = 52\%$. $F_{7,178} = 27.7$ ($p < 0.000001$). ns, not significant.

TABLE V. Percentage Change in FEV_1 and FVC per Year of Age, per Kilogram of Weight, and per Centimeter of Height and for Silicosis, Tuberculosis, and Emphysema for Random Sample Ex-mineworker Study Subjects, Libode District, 1996[a]

	FEV_1		FVC	
Parameter	% change	95% confidence limits	% change	95% confidence limits
Age (yr)	−1.0	±0.3	−0.7	±0.2
Weight (kg)	0.4	±0.3	0.2	±0.3
Height (cm)	0.7	±0.5	0.8	±0.4
Silicosis	−10.3	±6.1	−8.8	±5.0
Tuberculosis	−9.5	±6.4	−9.0	±5.2
Emphysema	−19.2	±10.2	−11.3	±8.4

[a]See text for details of the model.

combination of these diseases. However, setting the cut-off at 0.7 does not identify a large number of people who are suffering from one or more of these diseases; the histogram indicates that it may be more appropriate to use a cut-off at 0.75. Further investigation concerning both this and alternative measures of lung function are in progress, as is an analysis of the impact of pneumoconiosis, without tuberculosis and emphysema, on lung function, and will be presented in subsequent papers.

Compensation Results

All cases from this study have now been assessed by the certification committee of the Medical Bureau for Occupational Diseases (MBOD). Twenty-four percent (56) of the sample have been certified by the MBOD as having a compensable occupational lung disease. Appeals are still pending. First-degree cases accounted for 36%, and second-degree cases accounted for 64% of cases awarded compensation. Of those cases certified as eligible for compensation, 63% had no previous history of compensation, 35% had been previously compensated, but their disease had progressed and they were entitled to additional compensation, and only 2.5% had been paid in full and were entitled to no additional compensation.

DISCUSSION

The primary objective of this study was to evaluate the prevalence of undiagnosed as well as uncompensated occupational lung disease. In South Africa, compensation claims for occupational lung disease in mineworkers occur within the legal framework of the Occupational Diseases in Mines and Works Act [ODMWA, 1993]. The 1994 Leon Commission of Inquiry into Safety and Health in the Mining Industry reported that, in the 20 years before the commission, 128,575 mineworkers were certified with occupational lung disease. South Africa has had mining-related compensation legislation and a state run medical facility for mining related occupational lung disease since 1916, but access to this facility was reserved for white workers until the 1993 amendment to the ODMWA. Compensation payments were also based on race and favored whites over blacks. Access to the state run medical facilities for mining occupational lung disease was deracialized in 1993. However, access is still de jure and not de facto for the majority of former mineworkers as occupational health screening facilities are still almost entirely based in the areas in which white workers have

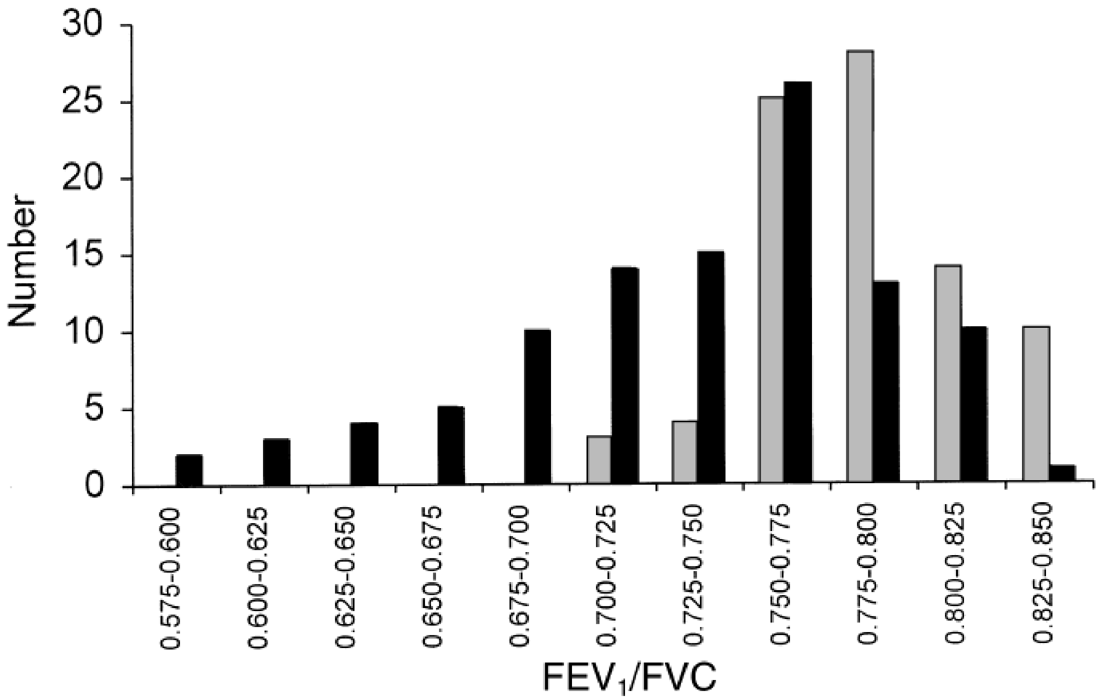

Fig. 1. Frequency distribution of random sample study subjects (described in the text) as a function of FEV_1/FVC after correcting for age, weight, and height. Darker bars, sick; lighter bars, healthy.

historically lived and not in the migrant labor-sending areas where most black workers return after leaving the industry.

This study was based in the major South African labor-sending area for the gold mines, the Transkei. The key economic determinant of the Transkei is its role as a labor reserve for industry in other provinces of South Africa. In 1991, 74% of total household income in the region was generated by migrant workers, working in other provinces. In 1995, a survey carried out amongst the families of migrant mineworkers by the Anglo American Corporation (AAC) in the Lusikisiki district, which borders on Libode, 93% of dependents of the migrant workers employed on AAC mines had no source of income other than mine wage remittances [personal communication, Dr. G. Herbert, 1997]. The male: female ratio in Libode district shows that between the ages of 20 and 44 yr, there are 30% fewer men than women. Although it is important to note that we do not know the gender- and age-specific mortality rates for this community, this ratio provides an estimate of the upper limit of the proportion of men who were migrants for the study area in 1991.

The results of this study show a high prevalence of radiological pneumoconiosis in a random sample of ex-mineworkers. It has also been demonstrated that there is a statistically significant association between total length of service and pneumoconiosis. Radiological evidence of pneumoconiosis, emphysema, and tuberculosis were all significantly associated with reduction in FEV_1 and FVC. These results concur with those of a previous study of occupational lung disease in a group of ex-mineworkers resident in the Kweneng district of Botswana which found the prevalence of radiologic pneumoconiosis to be between 26% and 31% [Steen et al., 1997]. The results also show the very high prevalence of previously uncompensated work-related disease in the study group.

This study highlights the need to ensure that current dust levels are kept at an acceptable low level. It also highlights the pressing need for occupational health surveillance in rural labor-sending communities. The low level of previously diagnosed occupational lung disease indicates a failure of detection mechanisms both on the mines and also in the labor-sending areas. Previous studies have shown that there is a low level of awareness of and compliance with the provisions of the ODMWA [Davies, 1994]. A combination of natural disease latency and social, political, and economic factors associated with labor migrancy have resulted in an externalizing of occupational disease costs away from the mining industry. The greater part of the costs of occupational lung disease are thus being borne by the labor-sending communities. The rural communities can be seen as subsidizing the production costs of the mining industry.

Externalizing the costs of occupational lung disease is extremely damaging for individuals, households, and communities in labor-sending areas such as Libode. In a context of low levels of education and high levels of dependency on physical labor as a source of employment, even a relatively minor degree of disability can be a major impediment to employment. Chambers argues ''the body is the poor person's greatest and uninsured asset. If this asset is devalued or ruined, from being an asset it becomes a liability that has to be fed, clothed, housed and treated. A livelihood is destroyed and a household is made permanently poorer'' [Chambers, 1989].

Most previous studies of occupational lung disease have been undertaken on in-service subjects. This study is one of the few that have been community based. Although the study design has yielded many insights into the methods one can use to trace and work with ex-mineworkers and their rural communities, it has also meant that the study group includes a wide range of exposure periods and latency periods. Furthermore, the cross-sectional design of the study only charts the disease status of living people who are not in service. It can be argued that men at home in the rural areas represent those selected out of active mining due to lung disease and that this could bias the prevalence data. Two points can be made in response to this argument. First, for this to be a plausible explanation, one would expect a higher number of previous certifications to have been recorded by the compensation authorities than the figures shown above. Second, if the random sample study group has been selected out of mining due to lung disease, it points to underreporting of occupational disease. Given that both tuberculosis and pneumoconiosis can adversely affect survival [Infante-Rivard et al., 1991], it is also possible that men alive and at home represent an aberrant ''healthy'' group who are in some way different from the large numbers of dead people in the random sample. It is impossible to establish cause of death for the dead people in the random sample; the lack of health infrastructure in rural Eastern Cape makes it impossible for the families of the deceased to obtain death certificates.

Because the two readers interpreted the ILO instructions differently, there were significant differences between the two sets of readings. Averaging or consensus reading is clearly inappropriate in a situation in which one reader diagnoses tuberculosis and the other diagnoses pneumoconiosis. For this reason, we have analyzed the data from the two readers separately; and, in the later part of the paper, used the results from reader 1 to demonstrate the relationship between the lung function measurements and the radiological diagnosis. The problems related to diagnosing pneumoconiosis in the presence of tuberculosis are clearly an issue in communities with high levels of both diseases. To try and resolve this issue, we hope to do a further study using computerized tomography, which might allow us to clearly separate pneumoconiosis from tuberculosis and use this to evaluate the usefulness of conventional X-rays in diagnosing pneumoconiosis in the presence of tuberculosis.

CONCLUSION

There is a high prevalence of previously undiagnosed, uncompensated pneumoconiosis in this study group. As a result of the failure to diagnose and compensate occupational lung disease in the major South African mine labor-sending area, the social and economic burden of such disease is being borne by individuals, households, and the migrant labor-sending communities as a whole. There are a lack of occupational health services in the areas to which the majority of mineworkers return after leaving the mining industry, and this lack of services has resulted in a de facto lack of access to the provisions of the ODMWA. This study highlights the need to take account of labor migrancy in the planning of occupational health services.

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REFERENCES

American Thoracic Society, Standardisation of Spirometry (1994) Update. Am J Respir Crit Care Med 152 1107–1136.

Beadle DG (1977): The relationship between the amount of dust breathed ant the development of radiological signs of silicosis: an epidemiological study of SA gold miners. In Walton WH (ed): ''Inhaled Particles IV, Part 2.'' Oxford: Pergamon Press, pp 953–964.

Becklake MR, Irwig L, Kielkowski D, Webster I, et al (1987): The predictors of emphysema in South African gold miners. Am Rev Respir Dis 135:1234–1241.

Callinicos L (1980): ''Gold and Workers.'' Johannesburg: Raven Press.

Chamber of Mines (1993): ''South African Mining Industry, Statistical Tables.'' Johannesburg: Chamber of Mines.

Chambers R (1989): Vulnerability, Coping and Policy. in IDS Bulletin 20:2.

Commission of Inquiry into Safety and Health in the Mining Industry (1995): Justice R.N. Leon, Chairperson. Department of Mineral and Energy. Pretoria.

Crush J (1995): Mine migrancy in the contemporary era. In James W, Crush J (eds): ''Crossing Boundaries. Mine Migrancy in a Democratic South Africa.'' Cape Town: IDASA.

Davies JCA (1994): Sound an alarm. S Afr Med J 83:133–134.

Eisen E, Dockery DW, Speizer FE, Fay ME, Ferris BG (1987): The association between health status and the performance of excessively variable spirometry tests in a population based study of six U.S. cities. Am Rev Respir Dis. 136:1371–1376.

Infante-Rivard C, Armstrong B, Ernst P, Petitclerc M, et al (1991): A descriptive study of prognostic factors influencing survival of compensated silicotic patients. Am Rev Respir Dis 144:1070–1074.

International Labour Organisation (1981): ''Guidelines for the Use of ILO International Classification of Radiographs of Pneumoconiosis.'' Occupational Safety and Health Series 22 (Rev.). Geneva: ILO.

Kleinschmidt I, Churchyard G (1997) Variation in incidences of tuberculosis in subgroups of South African gold miners. Occup Environ Med. 54:636–641.

MayerP (1980): ''Black Villagers in an Industrial Society.'' Oxford: Oxford University Press.

Minerals Bureau (1997): ''South African Mining Industry 1996–1997.'' Braamfontein: Department of Minerals and Energy.

Moodie D (1994): ''Going for Gold.'' Berkeley: University of California Press.

Musch D (1984): An application of kappa type analyses to interobserver variation in classifying chest radiographs for pneumoconiosis. Stat Med 3:73–83.

National Electrification Forum Database Task Team (1995): National Electrification Database. Johannesburg. Development Bank of South Africa.

Occupational Diseases in Mines and Works Act, Act 78, 1973, Government Gazette, 1973, 3970, ODMWA Amendment Act, 208, 1993, 15449.

Sluis-Cremer GK, Walters LG, Sichel HS (1967): Chronic bronchitis in miners and non-miners: An epidemiological survey of a community in the gold mining area in the Transvaal. Br J Ind Med 24:1–12.

Steen TW, Gyi KM, White NW, Gabosianelwe T, Ludick S, Mazonde GN, Mabongo N, Ncube M, Monare N, Ehrlich R, Schierhout G (1997): Prevalence of occupational lung disease among Botswana men formerly employed in the South African mining industry. Occup Environ Med 54:19–26.

Wiles FJ, Faure MH (1977): Chronic obstructive lung disease in gold miners. In Walton WH (ed): ''Inhaled Particles IV, Part 2.'' Oxford: Pergamon Press, pp727–735.

Wilson F (1985): Mineral wealth, rural poverty. Optima 33:1-–16.

Wilson F (1972) ''Labour in the South African Gold Mines.'' Cambridge: Cambridge University Press.

Wolpe H (1972): Capitalism and cheap labour power in South Africa: From segregation to apartheid. Economy and Society. 1:4–12.