Prevalence of occupational lung disease among Botswana men formerly employed in the South African mining industry

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Abstract

***Objective*—To determine whether previous health experiences affect the prevalence of occupational lung disease in a semirural Botswanan community where there is a long history of labour recruitment to South African mines.**

***Method*—A cross sectional prevalence study of 304 former miners examined according to a protocol including a questionnaire, chest radiograph, spirometry, and medical examination.**

***Results*—Overall mean age was 56·7 (range 28–93) years, mean duration of service 15·5 (range 2–42) years. 26·6% had a history of tuberculosis. 23·3% had experienced a disabling occupational injury. Overall prevalence of pnemoconiosis (> 1/0 profusion, by the International Labour Organisation classification) was 26·6%–31·0%, and 6·8% had progressive massive fibrosis (PMF). Many were entitled to compensation under South African law. Both radiograph readers detected time response relations between pneumoconiosis and PMF among the 234 underground gold miners. PMF could result from < 5 years of exposure, but was not found < 15 years after first exposure. Both pulmonary tuberculosis (PTB) and pneumoconiosis were found to be associated with airflow limitation.**

***Conclusions*—Former miners in Botswana have a high prevalence of previously unrecognised pneumoconiosis, indicative of high previous exposures to fibrogenic respirable dust. Their pneumoconiosis went unrecognised because they had no access to surveillence after employment. Inadequate radiographic surveillence or failure to act on results when employed or when leaving employment at the mines could have contributed to underrecognition. Community based studies of former miners are essential to fully evaluate the effects of mining exposures. Our findings indicate a failure of established measures to prevent or identify pneumoconiosis while these miners were in employment and show that few of the social costs of occupational lung diseases are borne by mining companies through the compensation system.**

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For more than a century the mining industry in the Republic of South Africa has been a major source of employment opportunities for the men of southern and central Africa. In 1992 mining in South Africa directly employed more than 600 000 people.[1] More than 90% of those employed are black, migrant workers from rural districts. Since the mid-1970s employment opportunities for citizens from South Africa's neighbours such as Botswana, Lesotho, and Mozambique have steadily declined. Before this date less than 30% of miners came from South Africa, whereas at present more than 70% are South African citizens.[2] Currently about 13 000–15 000 Botswanan citizens are miners in South Africa.

Mining, particularly deep level gold mining, has many direct and indirect health risks, including occupational injuries and lung diseases. It is estimated that in the past 20 years 128 575 mineworkers have been certified as having acquired occupational diseases. In the first 93 years of this century over 69 000 mineworkers died from occupational injuries and more than a million have been seriously injured. At current accident rates an 18 year old man starting a career at the stope face has a one in two to one in three chance of being permanently disabled from accident or disease.[3]

In South African medical fitness examinations, compensation, and some other aspects of occupational health in mines are governed by the Occupational Diseases in Mines and Works Act, Act 78 of 1973 (ODMWA). Silicosis, other pneumoconioses, chronic obstructive pulmonary disease, cardiorespiratory tuberculosis, and a variety of other occupational conditions can be compensated under the ODMWA. From 1980–9 between 1500 and 3500 black gold miners were certified annually under the ODMWA as having silicosis or silicotuberculosis,[4] giving a crude incidence rate of between 1·7 and 5·2 per 1000 currently employed miners per year.[5] This incidence is well below estimates of the prevalence of silicosis. For example, a 1987 study of active, black gold miners based on routine mass miniature chest radiography estimated the prevalence of silicosis to be 13·8 per 1000.[6] This estimate was thought to certainly be less than the true prevalence, given the insensitive method used.[7]

If statistics concerning pneumoconiosis in South African mines are underestimates, it is probable, given the size and age of the industry, that there are large numbers of former mine workers in southern Africa with previously unidentified disease that should be compensated. Little information is available from the industry or government departments responsible for such matters to estimate the magnitude of this problem. One previous study that directly considered a similar question was conducted in a rural district in South Africa, where asbestos was formerly mined.[8] Many retired miners with uncertified lung disease that should be compensated were identified, but because of very limited clinic facilities the study was not able to fully measure the size of the problem, although it seemed to be large. The limited available information has shown that occupational lung disease has a significant economic impact in economically marginal rural families or communities when it disables or is responsible for premature death in a family's most important economically active members.[9]

In view of the limited information available on a subject with substantial economic, political, and social implications, the present study was conducted to evaluate the health experiences of former miners and to estimate the magnitude of the problem of previously unidentified occupational disease in a semirural community with many former miners.

Subjects and methods

The village of Thamaga, Kweneng District, Botswana was selected for study, as this district is typical of many that have a long history of labour recruitment to South African mines. This particular village has a primary hospital with radiographic and laboratory facilities and there is a good relation between health workers and the community.

In April 1994 a house to house survey of the village (estimated population 14 400) was conducted. Altogether 1008 retired or former mine workers were identified. Of these, 220 were chosen with random numbers and were given letters inviting them to participate. This constituted the random limb of this study. At a general meeting (kgotla) of the village, retired miners with a long work history or chest problems were invited to attend, thereby constituting the open limb of this study. It was decided before starting the study that total participation would be limited to about 300, regardless of the limb into which participants were entered.

Both limbs were evaluated in the same manner. A structured interview was carried out in SeTswana to ascertain identification data, full occupational history, respiratory symptoms, and medical history. An examination was performed by a medical doctor. A chest radiograph was carried out in accordance with International Labour Organisation (ILO) specifications.[10] Spirometry was carried out by a trained technician with a Vitalograph compact spirometer (Buckinghamshire, UK). American Thoracic Society criteria for calibration for spirometry[11] were not fully met, as calibration was not done before the study started. Consequently only data relating to forced expiratory volume in one second/forced vital capacity (FEV_1/FVC) ratio were analysed. Chest radiographs were read into the ILO classification of the pneumoconioses[9] by one reader (NW, reader 1) with a second reader (RE, reader 2) reading the first 179 radiographs in a blinded, independent fashion.

In the event of suspected occupational lung disease, ODMWA forms were completed. Together with the chest radiograph and spirometry results, these were forwarded to South African authorities who administered the ODMWA.

STATISTICAL METHODS

Data were captured with EPIINFO (CDC, Atlanta, USA) and analysed with SAS (SAS Institute, Cary, NC, USA). A detailed subanalysis of results in underground gold miners was carried out, as this group was large and relatively homogeneous for the type of previous exposure. Student's t test and χ^2 tests were used to test for lack of homogeneity between subgroups for important variables.

Bivariate analysis investigated correlations between categorical outcome variables of interest (pneumoconiosis and airflow limitation) and variables relating to exposure (years of service, years since first service) with Spearman's rank correlation test. Multiple logistic regression analysis was used for the same outcomes, taking into account the effects of confounding variables age and smoking history.

Results

Altogether 304 former miners were entered. More were willing to enrol but could not be accommodated. Table 1 shows descriptive information about participants. This table also gives descriptive information about three subgroups for analysis—the random and open entrants into the study, and underground gold miners. Out of 220 invitees in the random group 101 attended, compared with 203 out of 888 possible eligible candidates in the open group. There were no significant differences between the two groups for a variety of important variables. There were more smokers in the open group (51·5% v 37·0%, $P < 0·05$). Underground gold miners were equally distributed between the open (158/203) and random (76/101) groups.

On average men had worked on 4·2 mines (range 1–11). There were 260 (85·5%) who had had most of their experience in gold mining, 234 (89·5%) had worked underground. Altogether 39 (12·8%) had worked in platinum mines and < 1% each in asbestos, chrome, and diamond mines and in a quarry. Participants' current economic status was mostly given as unemployed (46·4%), rather than retired (36·8%), 11·5% were working as labourers, and 3·2% were either business men, farmers, office workers, or traders. Figure 1 shows the distribution of dates of first and last exposure in mining. Most participants were exposed since 1960 with relatively few new recruitments since 1980. In all 173 men (56%) thought that they had a health problem

Table 1 Descriptive data of 304 former miners from Botswana and three major subgroups analysed in this study

	Total n = 304	*Random group n = 101*	*Open group n = 203*	*Underground gold miners n = 234*
Age (mean (SD))	56·7 (12·2)	55·7 (13·1)	57·1 (11·9)	55·8 (12·6)
Years in mining (mean (SD))	14·5 (8·2)	13·4 (8·7)	14·6 (8·1)	14·6 (8·0)
Pneumoconiosis ⩾ 1/0 ILO (%)	31·0	25·7	32·5	31·0
FEV_1/FVC < 70% (%)	20·5	20·2	29·1	27·2
Currently unemployed (%)	48·1	48·5	48·3	50·0
Do you cough first thing on waking up? (%):				
Yes	52·0	52·5	51·7	50·9
Do you smoke cigarettes? (%):				
Never smoked	37·2	41·4*	28·7*	37·2
Ex smoker	21·0	21·6	19·8	20·5
Current smoker	41·8	37·0*	51·5*	42·3
How is your health compared with others of the same age? (%):				
Better	36·2	40·6	34·0	34·6
Same	26·6	24·8	27·6	26·1
Worse	37·2	34·6	38·4	39·3
Have you ever been treated for tuberculosis? (%):				
Yes, once	20·7	21·7	20·2	22·6
Yes, > once	5·9	5·0	6·4	6·4
Were you ever compensated for injury or illness in South Africa? (%):				
Yes	27·3	22·8	29·5	29·1

*P < 0·05.

at present, caused by minework. The most common complaints were tuberculosis, cough, difficulties in breathing, chest pains, and painful extremities. At some time 117 had attended a local clinic for their problems. Applications for a benefit examination were completed for 182 men under the ODMWA. Among them were 34 men who lacked important documentary proof of previous mining employment.

RADIOLOGICAL INTERPRETATION

Both readers 1 and 2 read 179 radiographs for comparative purposes. There was a good correlation (*R* 0·7, P < 0·01) between their readings over the 10 point scale for profusion of small opacities with the ILO classification. Reader 1 read slightly higher prevalences than reader 2. Reader 1 classified 31·0% > 1/0 profusion compared with 26·6% by reader 2. Reader 1 recorded more high profusion readings (13·7% *v* 7·0% > 2/1). Both readers showed appropriate time response relations between their ILO profusion readings and years of exposure for underground gold miners (fig 2(A)).

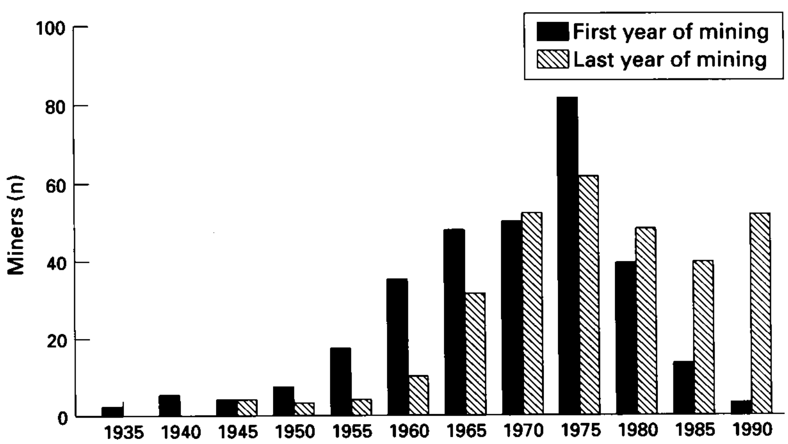

Figure 1 Mining experience of 304 Thamaga men according to first and last year of employment in South African mines.

UNDERGROUND GOLD MINERS

Table 1 shows descriptive data about the 234 former underground gold miners. Table 2 shows data from reader 1's ILO reading sheet for these 234 miners. Figure 2 shows the exposure time relations for pneumoconiosis and large opacities, analysed according to total underground exposure and years since first exposure. Prevalence of pneumoconiosis (> 1/0 ILO) was correlated with years of exposure to underground mining for both reader 1 (*R* 0·93, P < 0·05) and reader 2 (*R* 0·83, P < 0·05). Large opacities or progressive massive fibrosis (PMF) did not show the same correlation (*R* = 0·25, P = 0·51). There was a strong correlation with years since first exposure for both pneumoconiosis (*R* = 0·86,

Table 2 Percentage prevalence of radiological abnormalities with the ILO classification of pneumoconiosis in 234 former underground gold miners from Botswana (reader 1)

	Radiological abnormalities (%)
Film quality grade:	
1	41·2
2	46·4
3	11·2
4	1·1
Small opacities:	
Profusion grade:	
⩽ 0/1	69·0
1/0–1/2	17·3
2/1–2/3	10·5
3/2	3·2
Size and shape (by predominant type) grade:	
p	16·1
q	44·8
r	23·0
s	9·2
t	6·9
Large opacities grade:	
A	3·6
B	3·2
C	0·0
Pleural changes:	
Circumscribed plaques	1·5
Diaphragmatic plaques	2·0
Diffuse thickening	8·3
Costophrenic angle obliterated	14·8
Symbols:	
Tuberculosis*	23·9
Emphysema†	20·1

*Active or inactive tuberculosis.
†Typically based on features of hyperinflation.

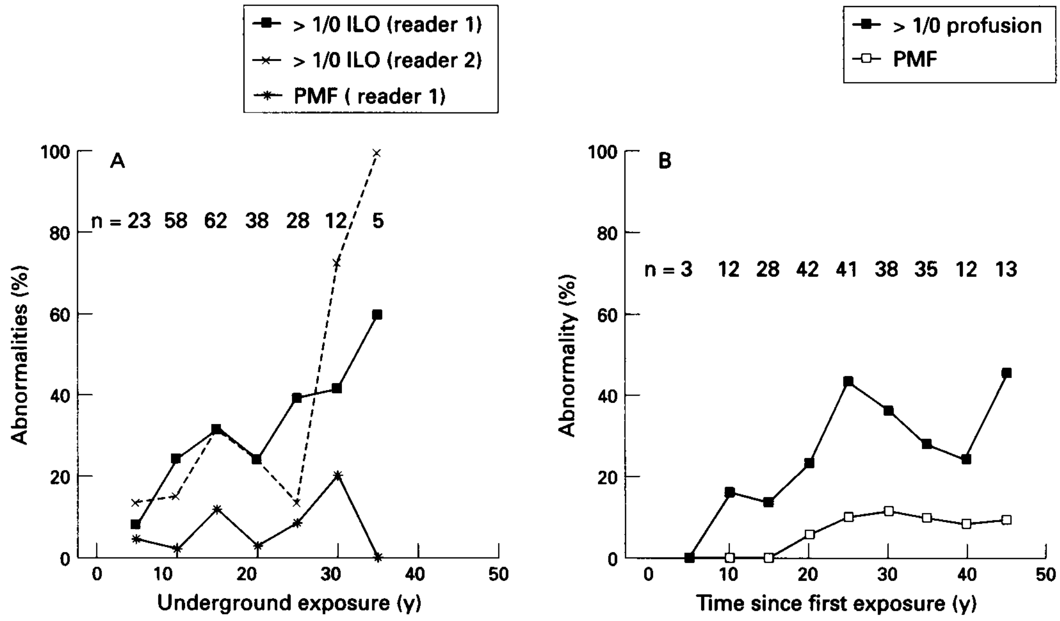

Figure 2 Percentage prevalence of pneumoconiosis (⩾ 1/0, ILO grade) and PMF (⩾ A, ILO) in former underground gold miners, (A) according to years of underground mining; and (B) according to years since first in underground mining.

P < 0·01) and progressive massive fibrosis (*R* 0·74, P < 0·05).

Although pneumoconiosis occurred in some miners after five or fewer years of underground exposure (fig 2A), it was not detected until six to 10 years after first exposure (figure 2B). Similarly, PMF was not read until 16–20 years after first exposure, although it was documented in men with fewer than five years of exposure. These findings indicate a latent period between exposure and manifestation of radiological abnormalities of at least five years for pneumoconiosis and at least 15 years for PMF.

TUBERCULOSIS

Four new cases of smear positive pulmonary tuberculosis (PTB) were identified during the survey (13·2/1000). Eighty men responded that they had previously been treated for tuberculosis. One in five had required retreatment. A total of 56 cases had been treated in Botswana, 24 in South Africa. Ten reported that they had been compensated in South Africa for PTB and one was uncertain as to what lung disease he had been compensated for. No participants reported having been compensated for pneumoconiosis, although the amounts received suggested that this had been the case.

A total of 29 gave dates of treatment for tuberculosis that coincided with the time that they were employed on mines, suggesting that more than 11 men had been eligible for ODMWA compensation for PTB. From these 29 cases, 42·3% occurred in the first five years of their mining experience. Seventeen, or 58·6% of these cases reported developing tuberculosis in their last year of mining—reflecting their medical separation from work after this diagnosis was made.

Figure 3A shows the age at which these 80 former miners reported first treatment for tuberculosis. Reported diagnosis initially accumulates with age at a uniform rate, both in those actively employed at the time of reported diagnosis and in those not working in mines at that time. The rate of accumulation of cases with age seems to slow after 50 years. When reported occurrence of tuberculosis is analysed in relation to employment history (fig 3B and C) it seems that the rate at which reported diagnoses accumulate increases when men start mine work and diminishes once they finish.

AIRFLOW LIMITATION

Airflow limitation was treated as a categorical variable, and was forced expiratory volume in one second/forced vital capacity (FEV_1/FVC) < 70%. Airflow limitation was found in 18·1% of men with no history of treatment for PTB, compared with 22·6% who had been treated once and 53·3% among those treated more than once (χ^2 = 10·1, P < 0·005). There was a good correlation between ILO grade of pneumoconiosis and frequency of airflow limitation, with airflow limitation being most frequent in those men with PMF (table 3).

MULTIVARIATE ANALYSIS

Airflow limitation (FEV_1/FVC < 70%) and pneumoconiosis (> 1/0, ILO) in underground gold miners were categorical outcome variables in multiple logistic regression with indicators of exposure (years of service, years since first service) and confounders (age, history of tuberculosis, smoking history, height, and weight). None of these variables explained the presence of airflow obstruction, although previous tuberculosis (odds ratio (OR) 1·7, P =

Table 3 Percentage prevalence of airflow limitation (FEV_1/FVC < 70%) according to ILO classification of pneumoconiosis

ILO grade	*Prevalence of airflow limitation (%)*	*n*
⩽ 0/1	18·5	151
1/0–1/2	23·7	38
2/1–2/3	34·8	23
⩾ 3/2	37·5	8
A or B	53·3	15

Figure 3 Cumulative occurrence of pulmonary tuberculosis in 80 Thamaga men according to (A) age at first diagnosis, (B) year of starting mine work in South Africa, and (C) last year worked in South African mines.

0·07) was the most important. Previous tuberculosis was the only significant explanatory variable for pneumoconiosis (OR 3·0, $P < 0.01$) in this model.

OCCUPATIONAL INJURIES

In all, 190 participants (62%) reported having been in hospital or given sick leave due to occupational injury while working in the mines. Of the participants 83 (27·3%) reported that they had previously been compensated for an occupational injury or disease. The occupational injuries reported by 71 (23·4%) participants were very diverse and the commonest could roughly be categorised as finger injuries 5·6%, lower limb fractures and dislocations 4·0%, finger amputations 3·3%, upper limb fractures and dislocations 3·3%, multiple injuries 1·3%, and eye injuries 2·3%, including three men with total blindness caused by chemical burns. Amounts awarded in compensation ranged from R5 to R31 000, with an average of R841·86 (at time of going to press R7·8 = £1).

Discussion

This survey is one of the few community based enquiries into the health of black miners who have been employed in the South African mining industry. It has provided unique and important information that justifies expanded efforts to screen former miners in Botswana and elsewhere. It provides new insights into the natural history of silicosis in South African gold miners. Significantly, it indicates a failure of measures to prevent or identify pneumoconiosis while these men were in employment.

About 30% of former miners responding to the survey had pneumoconiosis, many of them probably certifiable under South Africa's ODMWA. Very few of them had been compensated, indicating a poor performance of systems set up under the ODMWA. If the 40 miners with > 2/1 ILO grade pneumoconiosis identified by this survey received an average ODMWA compensation of R30 000, this survey indicates that about R1·2 million could be remitted to those entitled to it in Thamaga.

The most serious cause of chronic lung disease in this population was PTB and many cases seemed not to be directly related to mining. It can only be compensated under the ODMWA if it occurs in service or within a year of leaving mining. Ten out of a possible 29 miners said that they had been compensated for PTB, and one was unsure. Until, and even since, 1985 a diagnosis of PTB has resulted in immediate repatriation of black miners with an accompanying lump sum payment, as was reflected in our analysis of the occurrence of PTB in relation to ending employment (fig 3C). Since 1985 many miners with PTB have been allowed to continue working, while and after receiving supervised, short course, ambulatory chemotherapy.

Pulmonary tuberculosis, and particularly retreatment of PTB, was associated with airflow limitation, as was pneumoconiosis. Other studies have shown that the biological effect of working in an underground gold mining is equivalent to the effect of smoking 20 cigarettes a day,[12,13] or an estimated average annual decline of 7 ml FEV_1 a year. Our study did not have the sensitivity to detect such effects.

In multivariate analysis a history of PTB was the most important predictor (OR 3·0) of a radiological reading of pneumoconiosis. The relation between these two enitities is bidirectional as patients with silicosis are at increased risk of PTB and previously treated PTB may have been read and classified as pneumoconiosis, particularly when the reader was blinded to any history and when there was extensive abnormality. Even without blinding the accuracy with which the plain chest radiograph discriminates between the two conditions is questionnable. Postmortem examinations of gold miners in South Africa have previously shown that among men certified during life on radiological evidence by an expert panel as only having PTB, about 50% will have evidence of pneumoconiosis when they are rigorously examined.[4 9] This lack of specificity of the chest radiograph in a situation where there are two conditions in high prevalence remains problematic.

The fact that very few of the participants seem to have been previously diagnosed as having pneumoconiosis is one of the most striking findings of this survey and needs an explanation. Pneumoconiosis will be systematically underidentified if it progresses after exposure ends and no follow up examinations are done. Our findings indicate that this is the case for silicosis as experienced by this group of underground gold miners. Progressive massive fibrosis in particular is unlikely to be identified while miners are in employment. We have shown that although these men had worked for an average of 14·7 years in gold mines, PMF was not found less than 15 years after first exposure. This finding confirms the need for follow up examinations on former miners, something that is currently regularly practised at only a few centres in the subcontinent. We have shown that at least one out of every five miners with pneumoconiosis will ultimately have PMF.

For 40 years or more, the medical services on South African mines have used mass miniature chest radiography as a periodic screening method applied only to black miners for both PTB and pneumoconiosis. It is well known that this method is less sensitive than standard sized chest radiographs in detecting pneumoconiosis.[14] The lack of sensitivity of miniature radiographs for pneumoconiosis is a bias capable of systematically excluding of black miners from ODMWA benefits, through failure to identify the presence of pneumoconiosis. This lack of sensitivity is worsened by poor quality radiographic interpretation.[7] Inspection of mine radiographic records by South African state health officials has repeatedly resulted in numerous new certifications of pneumoconiosis after rereading the screening radiographs.[4]

The primary responsibility for detecting and reporting pneumoconiosis in black miners lies with medical officers employed by mining corporations. There is some evidence that before 1985 medical officers of the South African mines deliberately underreported pneumoconiosis because of the legal requirement that this diagnosis should result in repatriation of miners.[2 5] This practice was justified by doctors on the basis that it was better for the miner to continue working than to take a small lump sum (equivalent to less than a year's wages) and face probable unemployment.[2] Inaction after identification of pneumoconiosis by medical officers employed by mining corporations must be at least partially responsible for the low numbers compensated in this group of former miners.

Although failure to identify and report pneumoconiosis while these miners were employed seems a plausible explanation for why some of these men had not been compensated, the possibility also exists that cases had been reported and awarded compensation, but no money was actually ever received by the claimant. Repeated written enquiries sent to the South African compensation authorities on this point have yet to be answered and it remains a possibility that postal theft, fraud, or other similar activities are denying miners their compensation.

The study design of this survey is unusual in occupational health. Being community based, our study has included men with a wide range of exposure periods and latent periods from different mines. The design also raises the possibility of biases that could influence prevalence estimates. These include selection biases and survival biases in the population sample actually studied. Self selection of participants into our study on the basis of earlier or perceived ill health could increase prevalence estimates. We found no significant differences for adverse health events or pneumoconiosis between participants entered by either random selection or open invitation, indicating that self selection did not influence the prevalence of pneumoconiosis.

Our sample population did not comprise active miners, as they were not available in the community for study. If men were systematically selected out of active mining as a consequence of lung disease this bias would increase our prevalence estimates. For many years the ODMWA required that black miners with radiologically evident pneumoconiosis or PTB were excluded from employment (fig 3C). It could be argued that we have studied a population of unhealthy, non-workers, or the reverse aspect of the selection bias well known as the healthy worker effect. As we have shown, most of these men worked in South African mines before 1985. Time elapsed and the unavailability of new mining jobs for the men of Thamaga has also been important in selecting men out of employment in the mines.

Deaths from causes related to PTB or pneumoconiosis could influence our estimates of the prevalence of these conditions. Pneumoconiosis and tuberculosis can either separately, or together adversely affect survival and therefore select individual men out of the study population. Progressive massive fibrosis, present in 6·8% of these miners, has a well documented association with reduced life expectancy.[15] Given the cross sectional design of this study, it is not possible to be certain where survival effects are operating to lower prevalence in the various time response relations (fig 2).

Figure 4 shows the relation between pneumoconiosis (averaged between both readers) and duration of underground service compared with the benchmark study by Beadle *et al* of dose-response relations for respirable silica and pneumoconiosis in the South African gold mining industry.[16] This study of a cohort of white miners who first began work in 1930

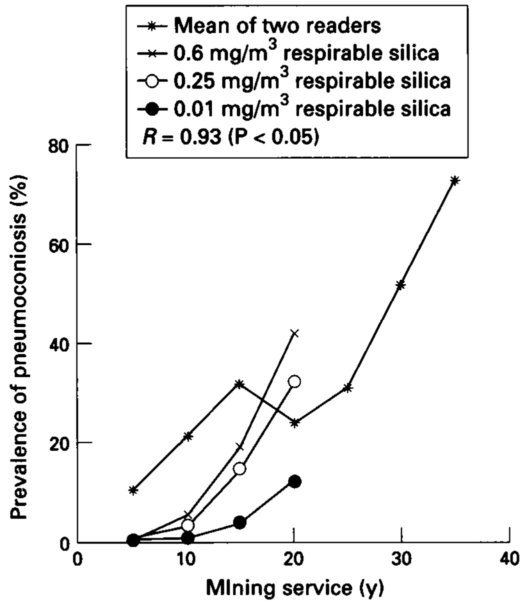

Figure 4 Percentage prevalence of pneumoconiosis (⩾ 1/0, ILO grade) in former underground gold miners from Thamaga by years of underground mining, compared with estimated dose response relation for respirable silica (mg/m³) and pneumoconiosis from another study.[16]

provided several dose-response curves for respirable silica and pneumoconiosis that have been approximated to current gravimetric methods of measurement. Miners were classified as having pneumoconiosis by only one reader, although this was before the advent of the ILO classification. Superimposition of the dose-response curves of Beadle *et al*[16] on our time-response findings suggests that, to have the prevalence of pneumoconiosis that we have documented, this group of Botswanan underground gold miners must have worked in areas where they were on average exposed to respirable silica of more than 0·6 mg/m³.

Selection biases and a sensitive definition of pneumoconiosis could partly explain the high prevalence of pneumoconiosis documented in our study. Nevertheless our results indicate exposures well in excess of averaged concentrations reported for the gold mining industry by the South African Government Mining Engineer over the years. Our findings accord with exposures as high as 0·72 mg/m³, respirable silica documented for shaft sinkers and other underground occupations in 1991.[17] It seems that there has been no significant change in dust exposure underground in gold mines for at least 50 years.[3]

There has been a recent exchange of letters that has sought to explain the very disparate estimates of risk of silicosis reported for Ontario hardrock miners[18] and South African gold miners.[19] For 40 years of exposure to 100 μg/m³, the estimated risks of changes on radiographs were 1·2% from the Ontario study and 60% from the South African study. Reasons for this discrepancy include: (*a*) the actual dust exposure of gold miners was underestimated in the South African study[20]; (*b*) the average proportion of quartz in respirable dust in South African gold mines was greater than the estimate of 30% used in the South African study[21]; (*c*) the quartz in South African mines is more fibrogenic than in the Canadian mines due to the higher percentage of quartz in the respirable dust,[22] or due to other properties of the dust; and (*d*) the South African study had older subjects at the end of radiological follow up.[21] Although this study does not contribute directly to answering this debate, the high prevalence of radiological changes in this relatively old population emphasises the relative fibrogenicity and long term effects of respirable dust in South African gold mines.

We have shown how the social costs of occupational lung disease were borne within this microcosm of southern Africa's migrant labour system. Thamaga miners experienced both the failure to prevent occupational disease and the failure of the ODMWA compensation system, meaning that all social costs from resultant disability were borne by families and the Botswanan government. Emerging evidence indicates that Thamaga is not an isolated example. Preliminary results from a survey of former mineworkers in the Libode district, Eastern Cape, South Africa have shown a higher prevalence of occupational lung disease than we documented. Chest radiographs of 150 men showed that 55% had pneumoconiosis (with or without PTB), and 36% had PTB (with or without pneumoconiosis); 32% had neither condition.[22] Extensive use of migrant labour and high levels of exposure to toxic quartzite dust in South Africa's gold mines have had the potential and the time to produce a silicosis epidemic on a grand scale. Further studies are needed to evaluate the extent of this problem. Preliminary indications are that it is very large.

Doctors in Botswana, and indeed other countries which have provided labour for South African mines, particularly those working with tuberculosis, should know about the compensation system under the ODMWA and how to file a valid claim. The Occupational Health Section, Community Health Services Division of Botswana should be strengthened to facilitate this process, and to work together with the Health Education Unit to inform doctors and district health teams about their responsibilities under the ODMWA. Miners and ex-miners need to be informed about their rights under the ODMWA and the particular importance of retaining documentation of their previous employment. Better ways of informing miners of these rights need to be developed together with trade unions, TEBA (the major labour recruiting organisation in southern Africa), mining corporations, and South African government authorities. The possibility of more active case finding among former miners in typical recruitment areas by way of a specially organised and equipped team needs to be investigated by the Botswanan Ministry of Health.

Mining is a dangerous and demanding occupation. This is reflected in the experiences of the men of Thamaga and the high prevalence of three major health events—disabling injuries, PTB, or pneumoconiosis. After an average of 15 years in mining, 46·8% were unemployed. The social costs of occupational disease had been borne almost entirely from within the community. These simple facts present a grim aspect of the mining industry in South Africa. Occupational Health and Safety in the mining industry has recently been considered by a South African government Commission of Inquiry. A new Mine Health and Safety Act has been promulgated following that Commission. The Act contains significant new measures aimed at improving the prevention and control of occupational injuries and diseases in South African mines.

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