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An Analysis of the Burden of Occupational Lung Disease in a Random Sample of Former Gold Mineworkers in the Libode District of the Eastern Cape.

Anna Trapido

A thesis submitted to the Faculty of Health Sciences, University of the Witwatersrand, in fulfilment of the requirements for the degree of Doctor of Philosophy

Uitzicht, 2000

Candidates declaration

I, Anna Susan Mollie Trapido declare that this thesis is my own work. It is being submitted for the degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

Anna Trapido

8 day of November 2000

Dedication

This thesis is dedicated to Richard Goode, Eliza-Jane Trapido and Thicket Goode.

Publications and presentations arising from this study

Publications

1. Trapido A, Mqoqi N, Macheke C, Williams BG, Davies JCA, Panter C. Occupational lung disease in ex-mineworkers. South African Medical Journal 1996; 86:559.
2. Trapido A, Mqoqi N, Williams B, White N, Solomon A, Goode R, Macheke C, Davies J, Panter C. Prevalence of occupational lung disease in a random sample of former mineworkers, Libode district, Eastern Cape Province, South Africa. American Journal of Industrial Medicine 1998;34:305-313.
3. Trapido A. The costs of gold mining related occupational lung disease to industry and society in South Africa. Journal of Mineral Policy, Business and Environment 1998;13:26-33.
4. Trapido A, Goode R. Polluters should pay. South African Labour Bulletin 1999;23:53-58.
5. Trapido A, Silent epidemic strikes former mineworkers. Crossings 1999;3:2-3.

Research presentations

1. Prevalence of occupational lung disease, Eastern Cape, South Africa. Harare Zimbabwe. Poster presentation at the Epidemiological Society of Southern Africa Conference 1995.
2. Preliminary results of a community based study of pneumoconiosis in a South African mine labour sending area. Accra, Ghana. Paper presentation at the Health and Safety Conference of the International Chemical, Energy and Metal Workers Federation 1996.
3. Occupational lung disease in a random sample of mineworkers formerly employed by the South African gold mining industry. Harare, Zimbabwe. Paper presentation at the International Symposium on Environmental and Occupational Health 1997.
4. Occupational lung disease in a random sample of mineworkers formerly employed by the South African gold mining industry. Johannesburg, South Africa. Lecture to Department of Mining Engineering, University of the Witwatersrand. 1997.
5. Occupational lung disease in a random sample of mineworkers formerly employed by the South African gold mining industry. Johannesburg, South Africa. Lecture to Diploma in Occupational Health Course, Department of Community Health, University of the Witwatersrand. 1997.
6. Participatory, community based studies of occupational lung disease in the Eastern Cape Province; research driven service provision. East London, South Africa. Paper

presentation at Region C, Department of Health Conference on Occupational Lung Disease in Ex-mineworkers. 1997.

7. Participatory, community based studies of occupational lung disease in the Eastern Cape Province; research driven service provision. Kokstadt, South Africa. Paper presentation at Region E, Department of Health Conference on Occupational Lung Disease in Ex-mineworkers. 1997.
8. An assessment of the strengths and weaknesses of the ODMWA compensation system. Johannesburg, South Africa. Paper commissioned by International Labour Organisation for the ILO Conference on Migrancy and Health in Southern Africa 1997.
9. Quantitative assessment of the costs of occupational lung disease in ex-mineworkers. Southern African Migrancy Project. Cape Town. 1998.

Abstract

South African gold mineworkers are exposed to high levels of silica dust and are at risk of developing occupational lung diseases. The majority of black mineworkers are migrant workers and diseases contracted while in employment often become apparent in the post-employment period once the worker has returned to the labour sending area. There is a legacy of racial discrimination in access to occupational health surveillance and compensation services.

To determine the occupational lung disease prevalence and previous compensation history of black, ex-mineworkers, a study was undertaken in a random sample of men living in Libode, a rural district of the Eastern Cape Province. Two hundred and thirty-eight ex-mineworkers were examined according to a protocol that included chest radiography and spirometry. Univariate and multivariate analysis of variance and co-variance was undertaken in order to investigate the associated risk factors of, interalia, age, length of service, smoking history. The extent to which study subjects were eligible for compensation was assessed and claims were submitted. The extent to which there had been a failure to compensate and the concomitant social and economic consequences were evaluated. A model to assess the extent of the compensation liability was developed and a strategy within which to rectify the situation was proposed. Finally, the consequences of this strategy for the economic viability of the gold mining industry were evaluated.

The prevalence of pneumoconiosis (ILO≥ 1/0) was 22 per cent – 36 per cent (variation by reader), 26 per cent of the study subjects were found to be eligible for compensation but only 2% of these had been paid prior to the study. Significant associations between length of mine service and pneumoconiosis and also between reduced FEV_1 and FVC and pneumoconiosis were found. The Libode group was found to be at greater risk of silicosis after short service periods, with greater variability in the rates of progression for the same average dust exposure than white South African mineworkers. The total cost of occupational lung disease, was estimated to be six per cent of the 1996 gold mining wage bill and 2.6 per cent of the gold mining industry's contribution to South African GDP. There is a need to raise the current compensation levy by 500 per cent to meet the unpaid liability.

Acknowledgements

In the performance of the fieldwork and the writing of this thesis I learnt a great deal from my co-workers. I hope that some of their wisdom has made it into the thesis.

In the planning stages of this project Mr Sabello Jadiso from the Libode Development Forum, Mrs Isabel Nompuku and Mrs Yoliswa Mzimba from the Eastern Cape Department of Health, Dr Clifford Panter from the National Centre for Occupational Health and Mr Oliver Sokhanyile from the National Union of Mineworkers helped me to build a relationship with the traditional leaders and civic structure leaders in Libode. In the subsequent community education phase I am grateful for the insights Mr Sizo Ngaloshe and Mr Les Bermister from TEBA Umtata. During the medical examinations the hard work and dedication of Dr Nava and the staff of St Barnabas Hospital, Mr Cecil Macheke of the Epidemiology Research Unit, Dr Meel at Umtata General and Mr Templeton Ntanyana at TEBA Libode is much appreciated. The tolerance of the ILO readers in reading radiographs that were not always of the best quality is not to be under estimated. During the processing of compensation claims Mr George Mbonde, Mr Elias Mabe and Mrs Christine Fritz at the Medical Bureau for Occupational Diseases and Mr Elijah Motsami at the Compensation Commission made it possible to follow up claims. Mr Richmond Zide skillfully acted as principle fieldworker. His dedication has contributed to building an enduring compensation service in the former Transkei.

Without the support of the traditional leaders and civic leaders in Libode this project would not have been possible. Despite the difficult nature of their relationship, the traditional and civic leadership of Libode worked tirelessly together to ensure that this project became a reality. Their ability to put aside their political differences and work for the common good shows them to be true leaders of their community. The enthusiasm that marked the participation of the ex-mineworkers in Libode was a joy to be a part of. The eagerness with which the ex-mineworkers of Libode took this project up and shaped its ultimate design was crucial to its success. I hope that they are enjoying their compensation money; they worked hard for it, first on the mines and later in helping me with the study.

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case with a view to appeal and writing increasingly acerbic notes to the MBOD Certification Committee. When the acerbic letters were insufficient, Mr Paul Benjamin gave us the legal muscle to get many legally invalid decisions overturned. Ms Nokuzola Mqoqi gave me invaluable epidemiological guidance, friendship and entrée into Libode society. Nokuzola is my model for the kind of woman and the kind of epidemiologist I would like to become. Professor Brian Williams encouraged me to be scientifically brave and quantitatively rigorous without loosing site of the community based nature of the project. I am extremely grateful to Professor Neil White who not only acted as an insightful co-supervisor but also defended the project from its detractors at the Chamber of Mines. I am also indebted to Ms Joan Cameron, who along with Nokuzola, held my hand when my fears of the enormity of the poverty and the potential for negative social fall out in Libode threatened to over-whelm me.

I would also like to thank Dr Stanley Trapido and Professor Charles Van Onselen who so incessantly 'talked miners' through my early childhood that they probably unwittingly engendered this project. Finally, I am grateful to Richard and Thicket Goode, Eliza-Jane, Cordelia and Cosima Trapido for their support, kindness and insight.

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Nomenclature

ATS	American Thoracic Society
BMI	Body Mass Index
CD plus T	Compensable disease plus tuberculosis
COIDA	Compensation for Occupational Injury and Diseases Act
COM	Chamber of Mines
COPD	Chronic Obstructive Pulmonary Disease
DME	Department of Minerals and Energy
DOTS	Directly Observed Therapy Short Course
FEV_1	Forced Expiratory Volume in one second
FVC	Forced Vital Capacity
HSE	Health and Safety Executive
ILO	International Labour Organisation
LIFO	Last in First Out
LLE	Loss of Life Expectancy
MBOD	Medical Bureau Occupational Disease
MDR Tb	Multi Drug Resistant Tuberculosis
MHSA	Mine Health and Safety Act
MOTTS	Mycobacteria Other Than Tuberculosis
MZAR	Million South African Rands
NCOH	National Centre Occupational Health
NIOSH	National Institute Occupational Safety and Health
NRC	Native Recruitment Company

NUM	National Union of Mineworkers
ODMWA	Occupational Diseases in Mines and Works Act
PMF	Progressive Massive Fibrosis
Pn	Pneumoconiosis
Pn plus T	Pneumoconiosis plus tuberculosis
Pn1	Pneumoconiosis in the first degree
Pn2	Pneumoconiosis in the second degree
SANCO	South African National Civics Organsisation
SMR	Standardised Mortality Ratio
Tb	Tuberculosis
TEBA	The Employment Bureau of Africa
TLV	Threshold Limit Value
VC	Vital Capacity
WNLA	Witwatersrand Native Labour Association
ZAR	South African Rands

Introduction

The extraction of South Africa's mineral wealth has exacted a considerable human cost. Gold mining entails an occupational exposure to dust with a high content of free crystalline silica. As a result of this exposure, gold mineworkers are at risk of developing occupational lung diseases such as pneumoconiosis, obstructive airways disease and tuberculosis. There can be a long latency period between exposure to risk factors and detectable occupational lung disease.

Since the discovery of gold on the Witwatersrand in 1886, labour migrancy has been central to the political and economic development of the gold mining industry in South Africa. The implications of labour migrancy for occupational disease are profound: diseases contracted while in employment may become apparent in the post employment period once the worker has returned to the rural labour sending area.

Gold mining in South Africa has also been characterised by racially discriminatory occupational health legislation and service provision. Until 1994, state funded occupational health surveillance services for former mineworkers were reserved for white mineworkers and compensation payments were based on race. As a result of this legacy, there is extensive occupational health surveillance service provision in the urban areas in which white mineworkers have historically lived but an almost total lack of surveillance facilities for ex-mineworkers in the rural mine labour sending areas from whence the majority of mineworkers are drawn.

While the evolution and contemporary form of the world's largest gold-fields has been extensively discussed and evaluated, the story of occupational lung disease in black migrant mineworkers and the impact of such disease on rural labour sending communities has been largely neglected. This thesis is based on an epidemiological study of the prevalence of occupational lung disease in a random sample of ex-gold mineworkers in Libode, a rural, mine labour sending magisterial district in the Eastern Cape Province of South Africa. This survey is the first occupational lung disease prevalence study to be undertaken in black South African ex-mineworkers. This research provides the first assessment of the medical, social and economic burden of occupational lung disease on individuals, households, rural communities and state funded health services. This thesis also evaluates the extent to which this burden has been externalised by mining employers.

South African occupational health literature has largely focused on urban, in-service workers and has consequently failed to explore the epidemiological significance of labour migrancy and its interaction with the long latent period that is a characteristic feature of pneumoconiosis. There is a considerable body of literature pertaining to mine accidents and acute conditions, such as tuberculosis, as they occur in in-service black and white mineworkers. There is also a limited amount of data pertaining to the long term consequences of dust exposure in white mineworkers, but hitherto no data have been collected and no systematic studies have been undertaken on occupational lung disease in black, former gold mineworkers based in rural areas.

It is well known that prevalence studies tend to suffer from Neyman's bias i.e. acute conditions tend to go unrecorded while chronic ailments come to the attention of the researcher. In a sense, labour migrancy inverts this bias, in that black workers have left the point of observation before conditions, such as pneumoconiosis, with long latent periods can manifest themselves. This bias (reverse Neyman's bias) has resulted in a considerable disease burden, with major social and economic consequences, going unrecorded. A tragic consequence of the lack of awareness of mining related occupational lung disease in rural communities has been that it has allowed the total lack of occupational health surveillance in rural areas to go largely unchallenged until the last half of the last decade of the twentieth century. As a result of the lack of occupational health services, a substantial burden of disease has gone undiagnosed and uncompensated. This has not only damaged rural households and communities but has also resulted in employer contributions to the relevant compensation fund that, the analysis in this thesis will show, are inadequate to meet the compensation liability. This research provides the first quantification of the extent of the unfunded compensation liability which takes into account the burden of disease in rural labour sending areas.

It can be argued that one of the most effective disincentives to hazardous working conditions is to ensure that the costs of disease and injury are directly borne by employers. This can be done through an efficient compensation system. This thesis shows that in South Africa the costs of gold mining related occupational disease have been largely externalised by mining employers and borne by rural households and state health services. Hence the economic link between hazard and disease has been rendered ineffective. To re-establish this link, a strategy and a time frame within which to provide all former mineworkers with a medical benefit

examination is put forward. The consequences of this strategy for the economic viability of the gold mining industry and relevant compensation fund are evaluated.

In chapter one of this thesis the political economy of gold mining in South Africa is evaluated. The occupational hygiene and health consequences of the cost structure of gold mining are discussed. The historical role that labour migrancy has played in the externalisation of disease is set out and the impact of recent moves towards labour stabilisation on occupational health are evaluated. The available data pertaining to occupational lung disease trends in black gold mineworkers over the course of this century are compared and contrasted with those pertaining to white workers and are discussed within the context of the political economy of the industry.

There is no published legal commentary on the Occupational Diseases in Mines and Works Act (ODMWA) and the institutions that it provides for. Chapter two undertakes an overview of the legislation and also critiques of the ODMWA relative to workers compensation legislation internationally and in the non-mining sector of the South African economy. This chapter also sets out the underlying principles of the ODMWA. It is argued that the ODMWA places mineworkers at a disadvantage relative to workers in other sectors of the economy.

Chapter three reports on the historical racial bias in the ODMWA and the impact that this has had on the financial viability of the ODMWA Compensation Fund. Finally, the extent to which the value of compensation awards and the value of employer contributions to the Compensation Fund have fallen in real terms since the inception of the ODMWA are computed and analysed.

In chapter four the medical, social and economic impact of the occupational disease burden for individuals and households in mine labour sending communities is assessed. Premature morbidity and mortality resulting from occupational disease are shown to have a substantial impact on the welfare of affected households and to contribute to the overall impoverishment of people and communities in labour sending areas. It is argued that the widespread failure to recognise the extent and importance of occupational lung disease whilst former mineworkers were still in employment, has resulted in the gold mining industry externalising significant costs and violating the ecological principle that the 'polluter must pay'. Quantitative and qualitative models to assess the cost of occupational lung disease to employers and society are described.

Chapter five sets out the legal framework pertaining to dust control in South African mines and reviews the clinical and epidemiological literature pertaining to silica dust exposure and subsequent development of mining related occupational lung disease. Reasons for the lack of epidemiologically useful occupational hygiene data are discussed. It is argued that the high prevalence and incidence of occupational lung disease suggests that, neither past, nor present, dust management practices are safe. The problems pertaining to the use of the international reference standards for classification of radiographs with pneumoconiosis, developed by the International Labour Organisation (ILO) in a South African context are put forward.

In chapter six, the economic, political, demographic and climatic conditions of the study area are described. The people of Libode are shown to have a primary dependence on mine wage remittances, a very limited agricultural base, high levels of illiteracy and limited access to health care. It is argued that these conditions make the study subjects very vulnerable to occupational health threats and that the significance of the cost of disease for household viability is high.

Chapter seven presents the study methodology. The strengths and weaknesses of the unique community-based methodology employed to define and trace study subjects are presented and there is a discussion of action and participatory research paradigms. Possible reasons for the lack of both local and international epidemiological data pertaining to migrant workers in the labour sending communities are discussed.

Chapter eight presents univariate and multivariate statistical analysis of the demographic, radiological, spirometric, respiratory disease symptoms and compensation data collected in Libode. Models to explain the progress of silicosis in relation to dust exposure in the study group, in white South African gold mineworkers and in two international studies of retired hard rock mineworkers are presented.

In chapter nine the data presented in Chapter eight are analysed and discussed. The relevant epidemiological literature is evaluated and it is shown that the study results are explicable in terms of the long-term material living and working conditions for black, migrant gold mineworkers. Reasons for the differences in the risk of silicosis relative to silica exposure between the study group and a group of white South African and two groups of international hard rock mineworker groups are discussed. Sources of potential bias in the Libode data are evaluated.

Chapter ten provides an assessment of the reliability of decisions made by the Certification Committee of the Medical Bureau for Occupational Diseases (MBOD) against radiological evidence of disease. It further assesses the efficacy of the office of the Compensation Commissioner. This analysis is based on case follow up of all 238 study subjects. The extent to which the Libode data suggests an under-reporting of compensable occupational lung disease is discussed.

In chapter eleven the data presented in the previous chapters are used to estimate the current liability of unpaid compensation under the ODMWA and to evaluate the implications of the disease burden for the future viability of the fund. Different scenarios for the likely extent of the future liability (depending on the impact of HIV and down scaling in the mining industry) are discussed.

Chapter twelve provides a quantification of costs of occupational lung disease currently being externalised by mining employers and borne by the state health services and rural households. A framework for increasing the number of medical benefit examinations available to former mineworkers in rural areas is set out and on the basis of this data, the difference between the potential and actual compensation liability is discussed. Finally, the prevalence of occupational lung disease and the extent to which this disease has been compensated in the study community are assessed. A proposal that would facilitate access by all former mineworkers to their legal rights under the ODMWA is suggested and the economic consequences of this proposal are discussed.

In chapter thirteen, the extent to which the dust levy would have to be raised in order to meet the actual compensation liability is examined. The impact of increasing the employer contribution to the ODMWA dust levy is discussed in relation to increasing production costs and cut off grades for economically viable ore in the South African industry.

The thesis is concluded with an assessment of the extent to which the initial research objectives have been fulfilled and a discussion as to the ways in which this investigation has made a contribution to new knowledge.

CHAPTER 1

The Political Economy of Health in the South African Gold Mining Industry; Past, Present and Future

"In a way it is even humiliating to watch...miners working. It raises in you a momentary doubt about your own status as an 'intellectual' and a superior person generally. For it is brought home to you, at least while you are watching, that it is only because miners sweat their guts out that superior persons can remain superior. You and I and the Archbishop of Canterbury and Comrade X, author of 'Marxism for Infants' - all of us really owe the comparative decency of our lives to poor drudges underground...with their throats full of dust driving their shovels forward with arms and belly muscles of steel."

George Orwell, Down the Mine

1.1 Introduction

The 'comparative decency' of life in modern, urban, industrialised South Africa is founded largely on the wealth created by gold mining on the Witwatersrand. This wealth is the product of over one hundred years of the mobilisation of capital, labour and ingenuity. While the evolution and contemporary form of the world's largest gold-fields has been extensively discussed and evaluated, the story of occupational lung disease in black mineworkers and the impact of such disease on the rural labour sending communities from whence they come, has been neglected. This thesis is based on an epidemiological study of the prevalence of occupational lung disease and an assessment of the burden that it has placed on individuals, households and communities in the magisterial district of Libode, a rural, mine labour sending area in the Eastern Cape Province of South Africa.

Before considering the prevalence and burden of disease that is the focus of this thesis, it is important to understand the social and economic context within which these lung diseases occur. The conditions under consideration are occupational illnesses and it is thus essential to place the study subjects in the world of work where they were exposed to the occupational health risk factors concerned. Furthermore, black mineworkers have been migrants and the circumstances of their migrancy and knowledge of the conditions obtaining in the rural labour sending areas are also crucial to understanding the burden of occupational disease and its

impact on the mineworkers' lives. In this chapter, the specific characteristics of South African gold mining, their interaction with underdevelopment in rural labour sending areas, and their implications for occupational health, are examined in order to establish the context of this study.

1.2 Documenting occupational disease in black mineworkers

In South Africa it is difficult to establish historical trends for occupational lung disease in black gold mineworkers. The available data are limited, both in scope and in detail, and previous studies of health in the gold mining industry have failed to document rural health problems relating to labour migrancy. Smith argues that while there are numerous historical and sociological studies that focus on the economic environment and on the labour relations of the South African gold mining industry, these studies seldom treat health and safety as an integral part of mining.[1] The failure to consider occupational health as an integral part of the study of the mining industry has resulted in the significant social impact of disease and injury being ignored. Arguably, the impact of occupational disease on the labour sending areas has been one of the most profound, far-reaching consequences of mining in South Africa.

Failure to include health and safety in an overall assessment of the economic and social effects of mining also occurs in other countries. Benson, in referring to the written histories of the British coal mining industry, has argued that:

> "economic and labour historians would do well to remember that even in an industry as notoriously strike prone as coal mining, in a normal year between 50 and 100 per cent more working days were lost from non-fatal accidents than from industrial disputes." [2]

Not surprisingly, in a society divided by race as well as by class, information relating to disease patterns in black mineworkers is much more scanty than that relating to white mineworkers. Until 1994, access to occupational health services and diagnostic equipment differed according to race and these differences are reflected in the available data. Leger has argued that the records of the state-funded mining occupational disease surveillance institution, the Medical Bureau for Occupational Diseases (MBOD), illustrate clearly the relative paucity of data pertaining to black mineworkers for the period 1916 to 1990.[3] Until 1994, the MBOD provided a racially discriminatory service and did not undertake benefit

examinations for black mineworkers but, rather, collected reports from the mine health services and from district surgeons. There were differences in the diagnostic techniques and equipment available to white workers for benefit examinations at the MBOD and to their black counterparts on the mines and through the district surgeons. Full-sized chest X-rays were used to detect pneumoconiosis in white mineworkers, while miniature X-rays were used for black workers. Myers argues that miniature X-rays are neither sensitive nor specific for diagnosing pneumoconiosis.[4] White discusses the probable underestimate of the extent of chronic obstructive pulmonary disease amongst black workers that can be attributed to the lack of pulmonary function testing equipment in many mine and rural hospitals.[5] Pulmonary function testing equipment is regarded as essential for the diagnosis of chronic obstructive airways disease. Furthermore, while the MBOD provided follow-up services for retrenched and retired white mineworkers, it did not follow up black workers once they left the mining industry. Silicosis, the most common form of pneumoconiosis on the South African gold mines, can both progress and manifest many years after a patient has left the source of exposure to silica. Many black mineworkers may have developed symptoms after returning to labour sending areas where occupational health awareness and health facilities for the detection of occupational lung disease are even now inadequate, and until recently, were non-existent. Failure to follow up black mineworkers once they had left the mining industry may have introduced a bias into the reported data through the healthy worker effect. A good example of the failure to provide follow-up medical examinations is to be found in the *Miners' Medical Bureau Annual Report* of 1968/9, which states that:

> "during the year 30 examinations were carried out in neighbouring states - 1 in Swaziland, 16 in Lesotho, and 13 in Rhodesia."

In 1968/69 there were over 300 000 employees who were migrants from outside South Africa. A second reason why available records underestimate the prevalence of occupational disease amongst black workers pertains to differing conditions of employment. Prior to 1983, black mineworkers were subject to compulsory medical repatriation in the event of tuberculosis being reported to the MBOD and anecdotal evidence suggests that some mine doctors were reluctant to report tuberculosis because of the economic consequences for the worker.[6]

The reliance by historians on the written record has resulted in black mineworkers receiving little attention in the published histories of occupational lung disease. Lack of documentation has sometimes been erroneously taken to mean absence of disease. Even the work of Katz,

which disputes the notion prevalent among employers and in the medical literature that black mineworkers were not as badly affected by silicosis as white mineworkers, still relegates silicosis in black workers to a ten-page discussion in an extensive, 220 page study of silicosis in white miners.[7] Even those studies that do examine occupational health in black mineworkers fail to document rural health problems relating to labour migrancy. Feirerman has argued that those responsible for reporting on the health of mineworkers focused their attention on certain types of data.[8] Thus, while accidents are relatively well reported because they happen in the workplace, diseases with a long latency period are poorly reported because mineworkers are migrants and return home before their diseases manifest themselves. An exception to this is the work of Packard, who devotes a chapter in his book *Tuberculosis and the Political Economy of Health and Disease in South Africa* to mining and the effects of mine labour on the incidence and prevalence rates of tuberculosis in rural areas.[9]

There is a paucity of occupational health data for black mineworkers and former mineworkers and this is especially so for those who have left the mining industry and returned to rural labour sending areas. This bias in the written histories and the limited amount of quantitative data available, is especially problematic when one considers that black workers have constituted 85-90 per cent of underground workers and that the majority of black mineworkers have always been migrants from rural areas.[10] Where the health of black mineworkers is discussed, it is often done within the framework of the available historical sources, such as government commissions. To the limited extent that these commissions examined the health of black mineworkers, they almost always did so by taking evidence from white experts, often associated with the mining industry, rather than directly from the mineworkers themselves. Smith notes that where such testimony has been taken, as by the 1913 Buckle Commission, the State Archives in Pretoria have lost the record, and it was not until the time of the Leon Commission in 1994 that evidence was specifically sought from black mineworkers.

There are a few exceptions to the general lack of data pertaining to the occupational health of black former mineworkers. The studies undertaken by Felix,[11] Steen *et al.*,[12] Davies[13] and Arkles[14] are rare examples of community-based investigations of occupational lung disease and injury in black former mineworkers. The results of these studies all show the considerable, long-term, medical, social and economic consequences of risks to health in the workplace. Felix undertook a survey of pleural plaques as a marker for environmental

asbestos contamination in the Mafefe district of the Northern Province, South Africa. Felix paints a picture of workers who were drawn out of peasant farming into employment on asbestos mines where they and their families lived in areas heavily polluted by mining activity and uncontrolled asbestos dumps. Steen *et al.* undertook a prevalence survey of occupational lung disease amongst a random sample of former gold mineworkers in the Kweneng district of Botswana, and demonstrated a significant burden of pneumoconiosis and tuberculosis. Davies, in his study of former asbestos workers in the Northern Province, South Africa, had what amounts to an extended case series, so large in size that despite not being a random sample, it provides a clear picture of the scale and magnitude of the burden of occupational lung disease in that area. In addition to the community-based work on disease, Arkles investigated the quality of life of mineworkers living in Lesotho and who had been permanently disabled by mine accidents. In the same study, Arkles described a systematic transfer of handling of the consequences of occupational injury to the communities from which the migrant workers originated.

This thesis is a study of the prevalence of occupational lung disease in a random sample of former gold mineworkers and also an assessment of the burden that the disease has placed on individuals, households and communities in the magisterial district of Libode. It also assesses the economic consequences, for modern mining employers, of providing for the compensation liability that currently exists. This survey in Libode is unique in that it provides the first occupational lung disease prevalence data for a random sample of black South African former gold mineworkers. The study is also unusual in methodological design in terms of the extent to which community organisations (political movements, unions, civic organisations, traditional leaders, etc.) and public authorities (health-related departments within local, regional, provincial and national structures) participated in the planning, implementation and service provision based on the study findings.

1.3 Political economy of gold mining

Following the discovery of the Kimberley diamond fields in 1879 and gold on the Witwatersrand in 1886, South Africa was transformed from a largely agricultural economy into a society with a capitalist mining industry at its centre, upon which the rest of the Southern African sub-continent became economically dependent. The ore body on the Witwatersrand is of low grade, but is very extensive, making it the world's largest gold field. The gold is contained in narrow seams in reefs that stretch, in an arc, for over 300 kilometres;

from Heidelberg and Kinross in the east to Virginia in the south-west. The Witwatersrand gold fields are also unique because of the depth at which the ore is found, with payable reefs occurring at various levels down to 3500 meters and beyond.[15,16]

1.3.1 Economics of gold mining

Historically, the cost structure of the gold mining industry on the Witwatersrand has been determined by three key factors: the low-grade of the ore, the high overheads and the fixed price of gold until 1973. In order to work the Witwatersrand gold fields profitably, mining had to be carried out on a sufficiently large scale to make unit costs low enough to deal with the low-grade ore. Large sums of capital, specialised mechanical equipment and substantial quantities of labour were required.[17] The price of gold was fixed (in pounds sterling before the First World War and in US dollars after the First World War) because of its status in backing currencies in international monetary relations. Although the demand for gold exceeded supply, the high overhead costs could not be recouped via higher gold prices. The key to making profits was to control working costs, of which labour represented a major element. Innes has argued that control over labour costs was extremely important to the mining houses. Labour constituted up to 60 per cent of operating costs in the early gold mines, and hence control over the price of labour was the single most important cost factor that the industry could influence.[18] The struggle to control and reduce labour costs has dominated mining labour relations since gold mining began on the Witwatersrand, and continues to do so.

The large-scale nature of the South African gold mining industry resulted in the development of the mining house as an institution in the South African economy. The mining house provided the structure for the mobilisation of European capital and, by pooling scarce resources and expertise, they were able to lower operating costs and spread risks across several mines. The mining house structure made South African mines an attractive option for foreign investment.[19] The six large mining houses (Rand Mines, Union Corporation, General Mining Corporation, Gold Fields Corporation, Johannesburg Consolidated Investments and Anglo American Corporation) that rapidly came to dominate the industry, generated 200 million pounds sterling (1920 pounds) in foreign investment over the first twenty-five years of gold mining on the Witwatersrand.[20]

1.3.2 Health consequences of the cost structure of gold mining

Smith argues that investors demanded high returns on their often risky investments.

Consequently, they introduced cost-cutting policies with regard to wages, diet, living and working conditions. A crucial consequence of this was the neglect of health and safety, especially in relation to dust prevention, which was often seen as an unnecessary expense.[21] The cost structure of the gold mining industry can be seen to have had an impact on the prevalence of both tuberculosis and pneumoconiosis in mineworkers. As Dubos argues 'tuberculosis was perhaps the first penalty that capitalistic society had to pay for the ruthless exploitation of labour.'[22]

The discovery of gold on the Witwatersrand brought large numbers of European immigrants to work on the mines, many from communities having a high prevalence of tuberculosis.[23] The workers who had migrated from Europe then came into close contact with black mineworkers. Exposure of the latter to tuberculous immigrants, combined with poor diet, physical stress and over-crowded conditions in compounds and mines contributed to making black mineworkers particularly vulnerable to contracting tuberculosis, which spread rapidly through the black mineworker population. An indication of the rate of spread of tuberculosis amongst black mineworkers is that whereas the 1903 report of the Miners Phthisis Committee indicates that the majority of workers with tuberculosis were European immigrants, the 1906 report of the Johannesburg Medical Officer for Health states that "there has been a very noticeable increase of tuberculosis among natives." By 1909, the annual tuberculosis mortality rate for black mineworkers on the gold mines was 6 per 1000.[24] This lead to an inquiry into the health of black mineworkers on the Witwatersrand being included in the brief of the 1912 Tuberculosis Commission.[25] Further support for the contention that mineworkers had a poor diet and experienced harsh working conditions can be gathered from medical data relating to diseases other than tuberculosis, such as scurvy. In November and December of 1926, there were 84 cases and 3 deaths from scurvy at Randfontein Mine alone.[26]

In the early decades of this century, the need to minimise costs in the gold mining industry resulted in crowded and unsanitary living conditions for black mineworkers. These living conditions led to very high rates of tuberculosis and pneumonia. Living conditions continue to be over-crowded today. In 1995, members of a government commission of enquiry into safety and health in the mining industry, visited a range of migrant worker mine hostels and found that on average, each room was occupied by between 12 and 20 men and that there was an average of $5m^2$ of space per person.[27]

The cost structure of the gold mining industry and the consequent neglect of dust prevention