HUT LUNG

A STUDY OF DOMESTICALLY ACQUIRED PNEUMOCONIOSIS IN RURAL WOMEN

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Dissertation presented for the

Degree of Master of Medicine

University of Cape Town August 1987

For JENNY and JULIE

ACKNOWLEDGEMENTS

The work described in this dissertation was undertaken at the Respiratory Clinic, Groote Schuur Hospital and the University of Cape Town under the supervision of Professor Eric Bateman whose help and guidance is gratefully acknowledged.

I am also endebted to the following for assistance given during the course of this research project:

- Mr. R.E.G. Rendall of the National Centre for Occupational Health, Johannesburg, who supplied the dust and smoke sampling equipment, arranged for analysis of the samples, and who accompanied me on the field trip to the Transkei.

- Staff nurse Patience Mdlatu and Nosikele Nongowuza who acted as interpreter and guide respectively during the field trip and Dr. J.I.G. Strang who arranged my introduction to them.

- Dr. G.D.J. Harloe of the Department of Pathology, University of Cape Town who reviewed the histology.

- Mr. Charles Skinner and his supervisor Professor A.M. Reid of the Department of Geology, University of Cape Town who analysed the rock and maize samples.

- I.H. Rong of the National Centre for Occupational Health who processed the microbiological samples of maize and those from the villages.

ABSTRACT

Pneumoconiosis in rural Transkeian women termed "Transkei Silicosis" has been thought to be caused by silica inhaled while grinding maize by traditional methods (Palmer and Daynes, 1967). This study was undertaken to investigate the features and causes of hut lung. The range of clinical, radiologic, histologic, pulmonary physiologic and broncho-alveolar lavage features in patients meeting the following criteria was assessed:

i) rural women practising traditional cooking methods
ii) with a diffuse nodularity on chest x-ray
iii) and lung biopsy evidence of pneumoconiosis
iv) and without occupational exposure
v) or evidence of active tuberculosis.

Smoke and dust levels were measured in rural dwellings during cooking and maize grinding and ground maize and grinding rocks were analysed.

25 patients were studied. 17 were non smokers, 5 were pipe smokers and 3 smoked 10 or less cigarettes per day. 7 had evidence of previous tuberculosis. The radiological findings ranged from a diffuse fine miliary pattern through coarse nodules with coalescence, to extensive fibrosis resembling PMF. The histologic features revealed simple "anthracosis" in 12, anthracosis with macules in 6 and mixed dust fibrosis in 7, of which 2 had silicotic nodules and 1 PMF. No such findings were observed in the control lung biopsy specimens obtained at post

mortem from city dwelling Xhosa females. Mild to moderate airflow limitation (defined as an FEV1/FVC ratio of < 65% and/or RV > 145% of predicted) was present in 73% while a reduced T'LCO (< 80% predicted) was found in 76% of the patients. Cell numbers and differential counts in BAL fluid were normal but > 80% of the macrophages were heavily laden with inorganic inclusions.

The mean smoke level during indoor open fire cooking was 30mg/m^3. Respirable dust and quartz concentrations ranging from 3,03 to 5,82mg/m^3 and 0,097 to 0,186mg/m^3 respectively were found during hand grinding with sandstone (100% quartz), but were lower (ranging from 2,62 to 3,40mg/m^3 and 0,024mg/m^3 respectively) when non-quartz containing dolerite was used. Calculated cumulative equivalent time-weighted average respirable dust concentrations were shown to be similar to those found in an average South African gold mine while calculated equivalent respirable quartz concentrations were well below those found in the worst exposed gold miners and well within the recommended threshold limit values of the National Institute for Occupational Safety and Health (NIOSH) and the World Health Organisation (WHO). Respirable quartz exposure alone was not sufficient to explain the changes found. Respirable non-quartz containing nuisance dust and intense smoke exposure were shown to be significant.

It was concluded that:

i) hut lung can be defined as a domestic pneumoconiosis that occurs in rural women who practise primitive cooking methods

ii) hut lung typically occurs in rural maize grinding Transkeian women but can occur in other rural women

iii) there is a wide clinical, radiological and histologic spectrum

iv) the pulmonary physiological changes are predominantly those of airflow limitation with some CO transfer factor reduction

v) cigarette and pipe smoking do not contribute to the aetiology or pulmonary physiological abnormalities

vi) the bronchoalveolar lavage features may help differentiate this condition from miliary tuberculosis

vi) the aetiology of hut lung is multifactorial with exposure to respirable quartz and non-quartz containing dust together with smoke particles from biomass fuelled fires all playing a significant role while previous tuberculosis may be a contributing factor.

STATEMENT OF CANDIDATE

I declare that the work on which this dissertation is based is original (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being or is to be submitted for any other degree in this or any other university.

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INTRODUCTION

Throughout history until the Middle Ages manual labour was felt to be unworthy of gentlemen. It was not until the days of Rousseau, Carlyle and Marx that manual work became accepted as a respectable vocation. Consequently occupational diseases attracted little attention until the middle of the 16th century when the first descriptions were published by Agricola in 1556, Paracelsus in 1567 and over a century later in 1700 by Ramazzini who is regarded as the father of occupational medicine. After Ramazzini's time there was a gradual increase in awareness of the risks of certain occupations with many social and industrial reforms taking place as a result of and after the Industrial Revolution. The occupational diseases of industrialised nations are now well documented and there are many excellent reference texts available (Hunter 1978, Parkes 1982, Morgan and Seaton 1984).

A universally neglected occupation however is that of the domestic labourer or housewife who has practised manual labour mainly of an agricultural nature throughout the ages. Almost every woman in the world is at some time involved with domestic activities and for many these activities make up their full time occupation. Most of these activities are benign but some of the more traditional methods of food preparation and cooking may not be as harmless as they seem. For this reason it was important to carry out a study of women with a history of domestic dust and

smoke exposure from primitive food preparation and cooking methods who had developed pulmonary abnormalities compatible with a pneumoconiosis.

The term "pneumoconiosis" requires definition because a variety of definitions have been proposed since Zenker first coined the term in 1866. A working group appointed by the International Labour Organisation (ILO) that convened within the framework of the IVth International Pneumoconiosis Conference in Bucharest in 1971 adopted a definition of a pneumoconiosis which is accepted by the World Health Organisation (WHO) and which will be accepted for the purposes of this thesis.

Pneumoconiosis is defined as an accumulation of dust in the lungs and the tissue reaction to its presence. Dust refers to an aerosol composed of solid inanimate particles. Pathologically pneumoconiosis may be subdivided into collagenous and non-collagenous forms depending on the fibrogenic or non-fibrogenic potential of the dust. In practice this distinction is difficult because there may be transition from a non-collagenous to a collagenous form of pneumoconiosis with continued exposure to a dust that does not normally cause collagenisation and because exposure to mixed dusts having different degrees of fibrogenic potential is far commoner than single dust exposure thereby causing a mixed picture. It should be noted that chronic pulmonary diseases developing as a result of exposure to inhaled dusts that do not accumulate in the lungs (e.g. Byssinosis,

Farmer's Lung and related conditions) as well as asthma, chronic bronchitis, emphysema and pleural diseases are excluded from this definition.

Two large surveys of disease patterns in rural South African Blacks carried out in the early 1970's by Edington et al (on 538 consecutive medical ward admissions to a rural mission hospital in Sekhukhuneland) and Van der Walt et al (on 8684 patients seen at 12 hospital points in the Ciskei) found respiratory diseases including pulmonary tuberculosis to be the commonest of the medical disease categories to occur in females with a prevalence of 29,9% being reported by the 1972 Transkei and Ciskei Research Society survey (Van der Walt et al 1983). The majority of these conditions were acute upper respiratory tract afflictions with pulmonary tuberculosis accounting for 24,7% of the respiratory illnesses.

Doctor's working in the Transkei have for many years recognized a condition occurring in the local women that is characterised by unexplained pulmonary fibrosis that manifests with diffuse radiological changes compatible with those of a pneumoconiosis and that may progress to cor pulmonale and death from cardio-respiratory failure. In 1967 Palmer and Daynes described this entity which they believed to be a pure form of domestically acquired silicosis caused by the inhalation of silica dust released during the preparation of maize meal by traditional methods. They labelled this condition "Transkei Silicosis". The term "hut lung" is used today to refer to any form of

domestically acquired pneumoconiosis occurring in rural women.

A major problem with this condition has been its differentiation from miliary tuberculosis and it has been postulated that in the past many patients have been committed to full anti-tuberculous therapy on the basis of suggestive radiological changes and respiratory tract symptoms when in fact they have actually had bronchitis superimposed on background "Transkei silicosis" (Palmer and Daynes, 1967). Because of the difficulties in establishing the diagnosis beyond all doubt in a rural environment epidemiological data as to the prevelance of the condition is speculative. The prevalence of "Transkei silicosis" was said to be 0,3% in the Transkei and Ciskei Research Society study although no details of the diagnostic criteria used were given and it is thus not possible to assess the validity of this figure. With the modern diagnostic techniques now available it has become possible to investigate such patients in order to make a definitive diagnosis and as a result of this it has become clear that hut lung encases a wide spectrum of abnormalities accompanied by an equally wide range of disability.

This thesis contains details of a two part study that was undertaken to investigate the features and causes of hut lung. The aim of the first part of the study was to investigate rural women with hut lung in order to determine the range of abnormalities found in these patients. A set of selection criteria that had to be met was defined. The nature of the

clinical, radiological, histological, pulmonary physiological and broncho-alveolar lavage features was defined. Bacteriology and basic haematology was also examined. The aim of the second part of the study was to determine the circumstances under which hut lung was acquired. A field trip was undertaken in order to measure smoke and dust levels during primitive food preparation and cooking and an attempt was made to analyse some of the constituents of the dust. Samples of the grinding rocks used as well as the ground maize produced were also analysed.

PART 1

THE STUDY OF THE PATIENTS

1) SELECTION CRITERIA

The study was both prospective and retrospective with the records of patients seen at the Groote Schuur Hospital respiratory clinic during the past 12 years being analysed. For inclusion all of the following selection criteria were satisfied:

i) Rural women with a history of exposure to domestic smoke and/or who have ground maize by traditional methods

ii) but with no history of industrial or mining exposure

iii) and with radiographic changes compatible with a pneumoconiosis

iv) as well as lung biopsy evidence of a pneumoconiosis

v) and the absence of bacteriological and histological evidence of tuberculosis.

2) METHODS

2.1) HISTORY

A good history of domestic exposure and a lack of mining or

industrial exposure was given by all the patients. The pattern of domestic smoke exposure and cooking technique of the average rural Transkeian woman was observed as part of the field study and did not differ significantly from the patterns described by the individual patients.

2.2) PREVIOUS TUBERCULOSIS

Evidence for previous tuberculous disease was sought for in all the patients especially those who gave a history of having had this diagnosis made at some time in the past. Where no details of confirmation of the diagnosis or of the treatment given could be obtained radiological changes compatible with previous tuberculosis were accepted as evidence of previous tuberculous disease. These changes included calcification of unilateral hilar or paratracheal lymph nodes and 2-3 cm parenchymal lesions or unilateral upper zone fibrotic changes in the absence of any other cause (ATS, 1980). Patients who had good evidence for previous non-pulmonary tuberculosis were also included in this group.

2.3) RADIOLOGY

The chest radiograph is the mainstay in the epidemiological investigation of pneumoconioses and is the sole means of detecting pulmonary retention of certain dusts e.g. silica and coal short of pathological examination of the lungs (Morgan and Seaton 1984). Radiographs taken for large epidemiological surveys

are standardised as far as possible in the techniques used for taking and for interpreting the films using the ILO classification of radiographs for pneumoconioses of 1980. The opacities observed are either rounded or irregular and are graded according to size. The profusion of the opacities is graded according to the scale of Liddell and May and the extent of the profusion graded according to the number of zones involved. Large pneumoconiotic opacities are also commented on and pleural involvement is recorded.

The chest radiographs of the patients in this study were all taken at Groote Schuur Hospital over a 12 year period using a variety of different x-ray machines and with the techniques not specifically conforming to the ILO recommendations. The radiographs were interpreted by the attending clinicians. Only 12 of the 25 radiographs were available for review. All of these were compared to the ILO standard radiographs.

2.4) LUNG BIOPSY TECHNIQUES

Lung specimens for histological assessment were obtained by the transbronchial route via a fibreoptic bronchoscope in 18 patients, by drill biopsy in 5 patients, by open lung biopsy in 1 patient and at post mortem in 1 patient.

The basic technique of fibreoptic bronchoscopy used in these patients has been described by others (Willcox et al, 1981).

After adequate local anaesthetic had been administered the bronchoscope was introduced transnasally if possible and routine inspection of all major lobar and segmental orifices was performed. Bronchial brushings in all and trap lavages in some were taken from one lung for bacteriological and cytological examination. Thereafter multiple transbronchial biopsies were taken from the same lung that had been brushed to avoid the potential complication of bilateral pneumothoraces. The brush and biopsy forceps were advanced under fluoroscopic guidance. After the procedure had been completed the patients were screened to detect pneumothoraces and chest radiographs were taken 2 to 4 hours later as a further precaution. The transbronchial biopsy specimens were submitted for histological examination in a 10% formaldehyde in normal saline fixative. In 18 patients one transbronchial biopsy specimen was placed in normal saline and sent for mycobacterial culture.

The drill biopsy technique used was that of Steel and Winstanley (1969). This method was however superceded by transbronchial biopsy via the flexible fibreoptic bronchoscope when the complication rate of the former was felt to become unacceptable.

2.5) HISTOLOGIC METHODS

All the specimens were fixed in a 10% formaldehyde in saline solution. Standard paraffin blocks were made from which sections were cut and stained with haematoxylin and eosin for examination under light microscopy. A Masson's Trichrome stain was used on

some of the specimens to assess collagen formation.

All the specimens were examined with polarised light for the presence of birefringent material which indicates the presence of organic matter such as collagen, amyloid, laminated fibrin, cellulose of aspirated plant matter and fascia of aspirated meat or inorganic matter such as silica, silicates and talc (Mark, 1984). To further differentiate birefringent material requires special procedures to remove unwanted tissue by incineration or digestion and the examination of the specimen by x-ray diffraction or with high quality optical equipment and having detailed knowledge of the physics of polarised light and crystallography (Kleinerman et al, 1979; Ziskind et al, 1976; Katzenstein, 1982; Wolman, 1970; Mark, 1984). These techniques are not generally available at routine surgical pathology laboratories and were not performed on the specimens from the patients with hut lung.

2.6) **HISTOLOGIC DEFINITIONS**

The histologic features observed in the lung biopsy specimens from the hut lung patients were divided into 3 categories that were defined as follows :-

(i) **Simple Anthracosis**

This is defined as carbon pigment deposition within the septal and perivascular areas as well as around the

terminal respiratory bronchioles but without macule formation. Anthracosis is an observation and not a diagnosis. Carbon by itself is relatively inert and even large amounts cause little or no fibrosis. The degree of carbon deposition does however serve as an indicator of overall exposure to both carbon particles and other air pollutants and when associated with moderate to severe fibrosis suggests the presence of other fibrogenic dusts (Mark, 1984).

(ii) **Anthracosis With Macule Formation**

This is defined as the presence of carbon pigmentation together with macules which are focal collections of dust laden macrophages occurring at the division of the respiratory bronchioles and that may also occur within alveoli and extend into the peribronchiolar interstitium with associated reticulin deposits. The smaller specimens from the transbronchial biopsies do not allow a full assessment for the presence or absence of focal emphysema to be made which if present would make these lesions indistinguishable from those found in simple coal workers' pneumoconiosis as defined by Kleinerman et al in 1979.

(iii) **Mixed Dust Fibrosis**

The characteristic histologic feature is an irregular or stellate interstitial fibrous lesion with variable pigmentation from the associated inert dust. The lesions occur predominantly in the area of the respiratory

bronchioles and adjacent small arteries. The fibrotic response ranges from a slight increase in reticulin in areas where there is no quartz to collagenisation and fibrosis that extends into the surrounding parenchyma in a both linear and radial fashion in areas where there is quartz present. Characteristic whorled silicotic nodules and the confluent lesions of progressive massive fibrosis are uncommonly seen. (Uehlinger, 1946; Harding, Gloyne and McLaughlin, 1950; Parkes, 1974; Katzenstein, 1982).

2.7) HISTOLOGIC CONTROL GROUP

The Pneumoconiosis Committee of the College of American Pathologists has described the very mild degrees of pigment deposition found in the lungs of normal non-occupationally exposed adults (Kleinerman et al, 1979). Small amounts of pigment may be found in a subpleural, perivascular and occasionally peribronchial and septal distribution.

A small control group of histological specimens was collected from post mortem examinations performed on 7 Cape Town dwelling Xhosa females who had died of non-pulmonary causes and who had clear lung fields on their chest radiographs. All had been city dwellers in conventionally ventilated houses all their lives and had not practised traditional cooking methods. The degree of pigmentation seen in these specimens as well as the presence of refractile particles when viewed under polarised light was

compared to the findings in the patients with hut lung.

2.8) PULMONARY PHYSIOLOGICAL MEASUREMENTS

Pulmonary function tests were performed on 22 patients in the lung function laboratory of the Groote Schuur Hospital respiratory clinic using standard equipment and methods. Forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1) were measured in all 22 patients. The carbon monoxide gas transfer (T'LCO) and KCO (gas transfer/litre lung volume) was measured in 17 and the total lung capacity (TLC) (helium dilution method) in 13 of these patients. The results were corrected to BTPS and expressed as a percentage of the predicted value for sex, age and height (Cotes, 1979; Schoenberg et al, 1978; Grimby et al 1963). These predicted values were accepted as standard for the Groote Schuur Hospital Respiratory Clinic.

The results of the lung function tests were regarded as being indicative of airflow limitation if on spirometry alone the FEV1 to FVC ratio was less than 65% or when spirometry and TLC values were available the residual volume (RV) was greater than 145% of the predicted value. A restrictive defect was diagnosed when the FEV1 and FVC values were proportionately reduced together with a reduced TLC. The T'LCO and KCO were regarded as being impaired if they were found to be less than 80% of their predicted values.

2.9) BRONCHOALVEOLAR LAVAGE

Bronchoalveolar lavage performed under local anaesthetic through a fibreoptic bronchoscope has been used since the mid 1970's as a diagnostic tool and to study the pathogenesis of disease (Reynolds and Newball, 1974). Bronchoalveolar lavage was performed on 6 of the patients with hut lung at the time of fibreoptic bronchoscopy.

After introducing the fibreoptic bronchoscope according to the method described previously the tip was wedged in a peripheral small bronchus usually in the right middle lobe. 20 ml aliquots of room temperature buffered normal saline up to a total volume of 200 ml were gently injected and then aspirated into a sterile siliconised glass bottle which was transported to the laboratory on ice for immediate processing.

The total cell yield was assessed by taking a small aliquot of the lavage sample, staining it with standard white cell counting fluid and counting it in an improved Neubauer counting chamber. The total count was then expressed as the absolute number of cells recovered and as the number of cells per ml of recovered lavage fluid. A total cell yield of up to 10×10^6 in a non smoker and 15×10^6 in a smoker is regarded as normal although the significance of these figures has not yet been proved to be of clinical value (Turner-Warwick and Haslam, 1986).

The remaining lavage fluid was then filtered through sterile

gauze if the specimen was contaminated with mucus. The cells were separated by centrifugation at 1600 rpm at 4°C for 10 minutes after which the supernatant was removed and the cells washed twice with Modified Eagles Medium and made up to a dilution of 2 x 10^6. A minimum of 3 cytocentrifuge preparations were then made from 100 microlitre aliquots of the cell suspension (2 x 10^5 cells/aliquot) that were fixed with a 1:1 chloroform and acetone solution, air dried for 30 minutes and then stained with a May-Grünwald-Giemsa stain in preparation for differential counting. A cover slip was applied with adhesive once the stain had dried.

The differential counts were performed with a standard light microscope using objectives of x20, x40 and x100 under oil immersion. A minimum of 300 inflammatory cells were counted using the random field counting method. A normal differential count consists of less than 11% lymphocytes, less than 3% neutrophils or eosinophils and less than 1% basophils. The alveolar macrophages of normal non smokers have clear cytoplasm with no or very few inorganic inclusions present. The alveolar macrophages of smokers have mild to moderate amounts of fine inorganic inclusions present.

2.10) **BACTERIOLOGY**

All bacteriological investigations were performed by the Groote Schuur Hospital Department of Bacteriology's routine laboratories. All 18 patients who underwent fibreoptic

bronchoscopy had bronchial brushings and a transbronchial biopsy examined for acid fast bacilli by the standard Ziehl-Neelson staining technique as well as having both specimens submitted for culture for Mycobacterium tuberculosis. Bronchoalveolar lavage fluid from 8 patients, the 5 drill biopsy specimens and the open lung biopsy specimen were all examined for acid fast bacilli and cultured for Mycobacterium tuberculosis. Two patients underwent liver biopsies and 2 patients had bone marrow examinations in search of bacteriological and histological evidence of tuberculosis. The bacteriological specimens taken from the 25 patients with hut lung are itemised below:

Bacteriological Specimens	Number
Ziehl-Neelson stain of lung tissue	- 24
TB Culture of lung tissue	- 24
Ziehl-Neelson stain of bronchial brushings	- 22
TB culture of bronchial brushings	- 22
TB culture of lavage fluid	- 8
Liver biopsy	- 2
Bone marrow biopsy	- 2

2.11) **HAEMATOLOGY**

Blood counts, differential cell counts and ESR's as well serum proteins were measured by the routine haematology and biochemistry laboratories at Groote Schuur Hospital according to standard methods.

3) RESULTS

3.1) DEMOGRAPHY

Twenty five patients were included in this study. The mean age was 49,3 years with a range of 20 to 84 years. Twenty two were rural Transkeians who gave a history of domestic smoke exposure and ground maize by means of traditional methods while 3 were so called Coloureds from Namaqualand who did not grind maize but who gave a history of heavy domestic smoke exposure from cooking on iron stoves heated by smoky wood fires in unventilated huts and who met all the other criteria for inclusion in this study.

3.2) CLINICAL FEATURES

a) Presenting Features

In 14 patients the finding of hut lung was incidental to the reason for presentation to hospital. Five of these 14 patients admitted to mild upper respiratory tract symptoms but none had felt that these were severe enough to warrant seeking medical attention. Six patients were referred from various tuberculosis institutions for investigation of persistent radiological changes in spite of what was felt to be adequate antituberculous therapy (ranging from 2 to 8 months). Three of these six patients admitted to respiratory tract symptoms. Four patients presented with upper respiratory tract symptoms with productive coughs and Grade 2 dyspnoea on exertion while 1 patient presented in cor pulmonale from which she ultimately died. Twelve patients overall

thus had no symptoms referrable to the respiratory tract.

Table 1

PRESENTING FEATURES AND SYMPTOMS

Presenting Features		**Resp Tract Sx**
Incidental finding	- 14	5
Persistent radiological change	- 6	3
Respiratory tract symptoms	- 4	4
Cor pulmonale	- 1	1
	25	13

b) **Coexistent Diseases**

Coexistent diseases were hypertension in 5 patients (2 of whom had left ventricular disease secondary to their hypertension), uterine fibroids in 2 patients, an incomplete abortion and viral encephalitis in 1 patient each respectively.

c) **Smoking Status**

Eight patients (32%) were smokers. Of these 5 were pipe smokers and 3 cigarette smokers who smoked between 1 and 10 cigarettes per day. The pipe smokers were all elderly rural Xhosas while the cigarette smokers consisted of all 3 the Coloured ladies from Namaqualand. The remaining 17 patients were non smokers.

3.3) PREVIOUS TUBERCULOSIS

Seven of the 25 patients had convincing evidence of having had previous tuberculous disease. Five patients gave a history of having had tuberculosis in the past for which they had received some form of therapy. No details of confirmation of the diagnosis or of the treatment given were available on any of these patients and thus only the 3 patients who had definite radiological evidence of previous tuberculosis were accepted as such. Three patients gave no history of previous tuberculosis but had typical radiological features that were regarded as sufficient evidence for previous tuberculous disease. This group included 1 patient who had evidence of previous presumed but not proven tuberculous pericarditis and disseminated tuberculosis.

3.4) RADIOLOGY

All the radiological features were compatible with those found in a pneumoconiosis. The changes ranged from a diffuse fine rounded regular nodulation resembling miliary tuberculosis through coarser irregular nodules to extensive fibrosis resembling progressive massive fibrosis (PMF). The profusion score of the radiographs that were reviewed ranged from 1/1 to 3/3 changes with all 6 zones being involved. One patient showed radiological features of cor pulmonale together with parenchymal changes compatible with a pneumoconiosis. No egg shell calcification of the hilar glands was noted in any of the

patients. Six of the 25 patients (24%) showed radiological changes compatible with previous tuberculous disease. All the patients with radiological evidence of calcification came from this group.

The spectrum of changes noted on the radiographs are shown in the following plates:

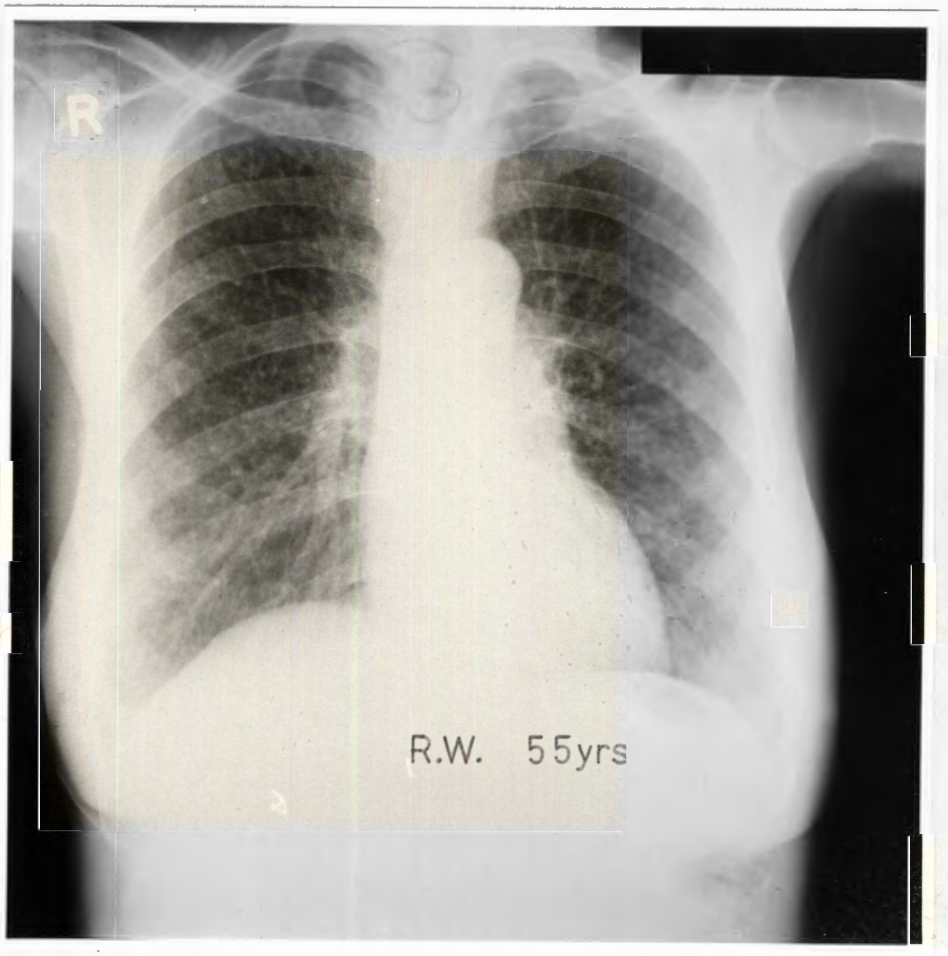


Plate 1: Diffuse fine rounded regular nodulation (Miliary pattern). ILO category - 2/2 q/q (tb).

Plate 2: Diffuse fine nodulation with calcium in the L hilum. ILO category - 1/0 p/p (tb).

Plate 3: Medium sized nodules with areas of coalescence and evidence of previous tuberculosis at the L apex. ILO category - 3/3 q/r (ax tb).

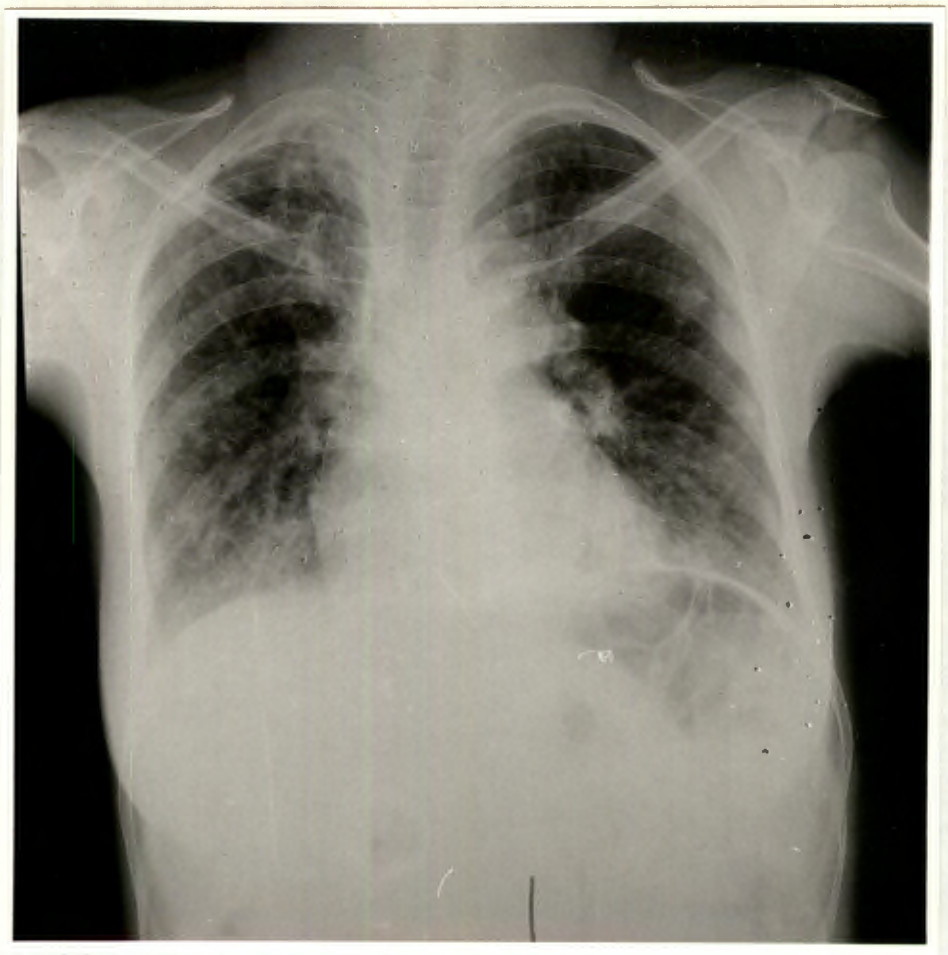
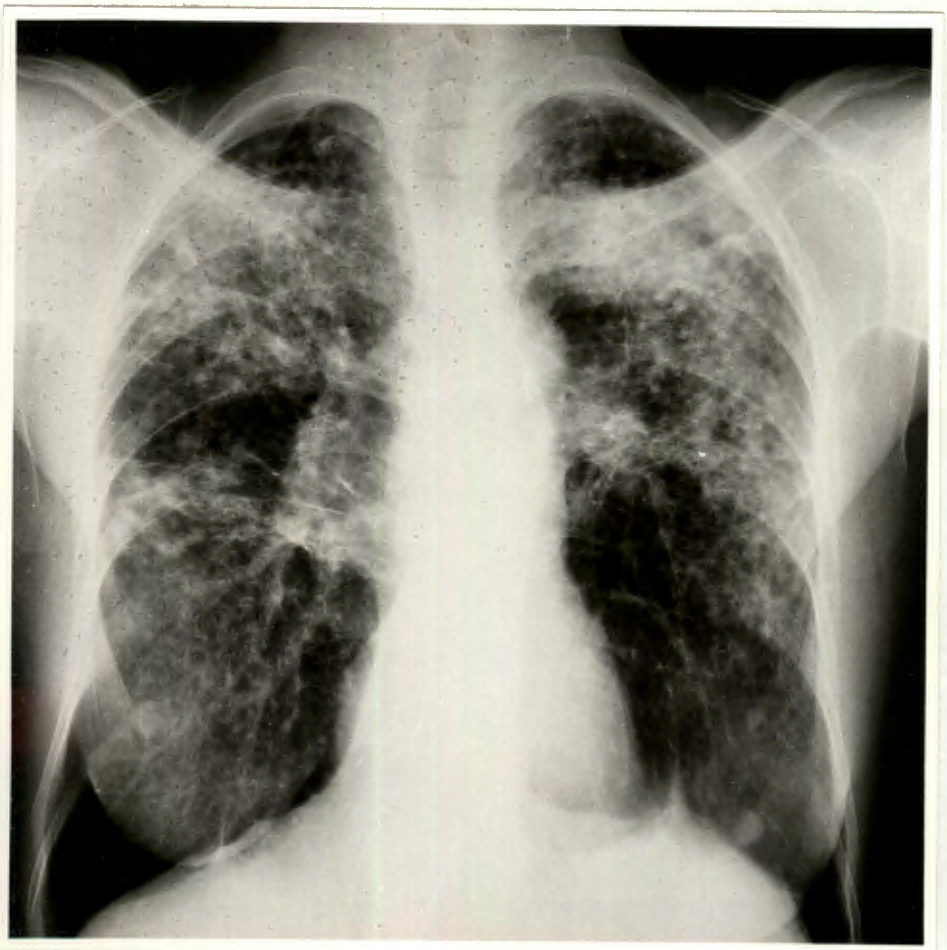


Plate 4: Irregular nodules, linear shadows and L hilar calcium. ILO category - 1/2 r/q (tb ax hi).

Plate 5: Coarse irregular nodules, extensive fibrosis and PMF. ILO category 3/2 r/r (ax).



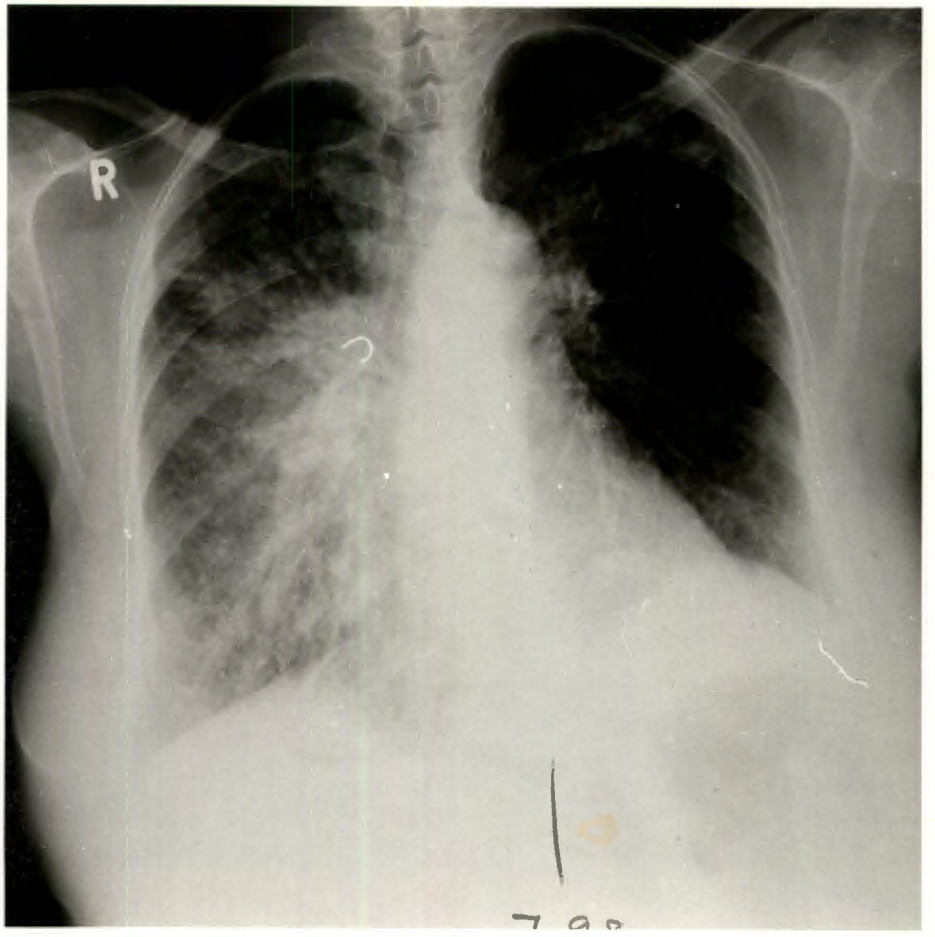
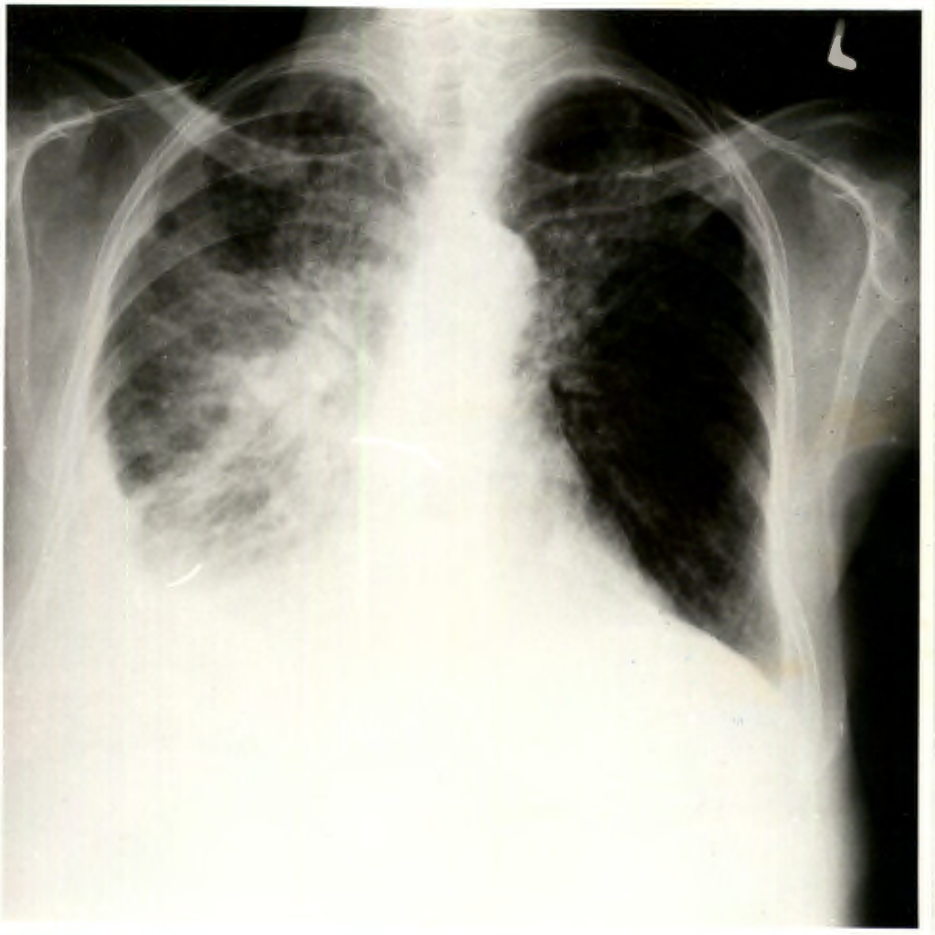


Plate 6: Nodules, coalescence, PMF and cor pulmonale. ILO category - 3/2 q/q (ax cp ef).

Plate 7: Above patient with large pleural effusion.



3.5) HISTOLOGICAL ASSESSMENT

The results of the histological assessment are shown in table 2:

Table 2

HISTOLOGIC FEATURES		
Simple anthracosis	- 12	
Anthracosis with macules	- 6	
Mixed dust fibrosis	- 7	(Including 1 patient with silicotic nodules and 1 patient with silicotic nodules and PMF)
Refractile particles under polarised light	- 18	

The histologic changes that were seen are illustrated in the following plates:

Plate 8: Simple anthracosis together with an anthracotic macule.

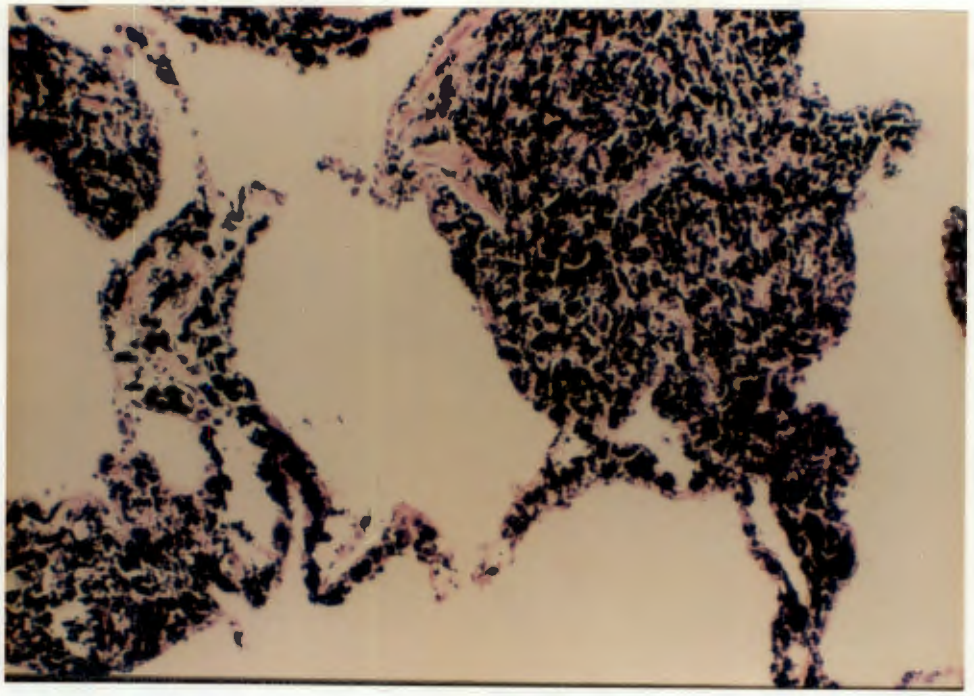


Plate 9: Anthracotic macule. Note the carbon laden macrophages within the adjacent alveoli.

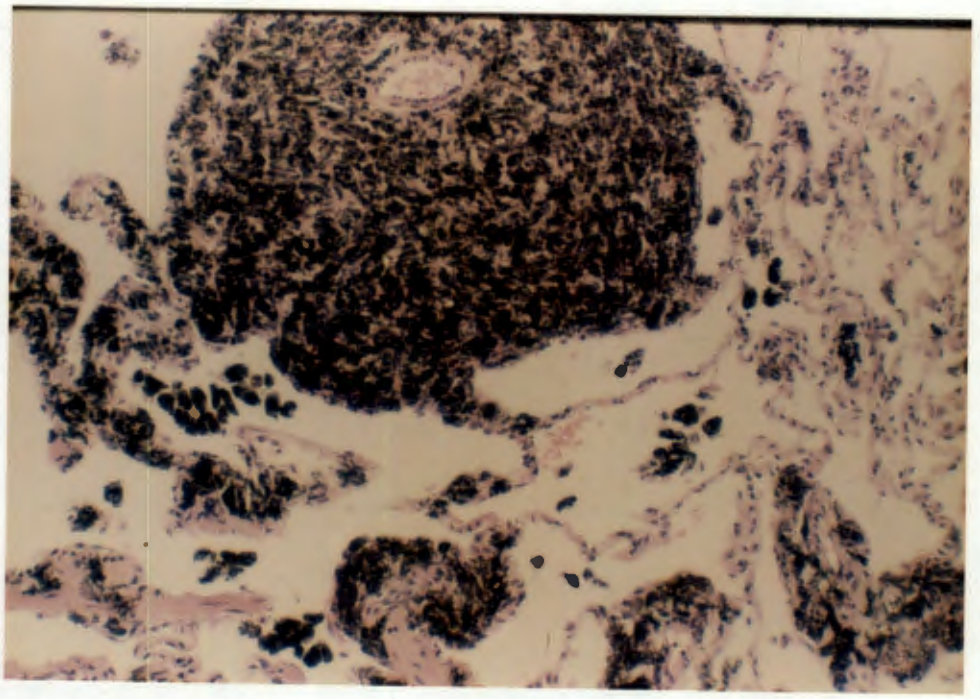


Plate 10: Masson's trichrome stain of an anthracotic macule showing minimal reticulin (dark green).

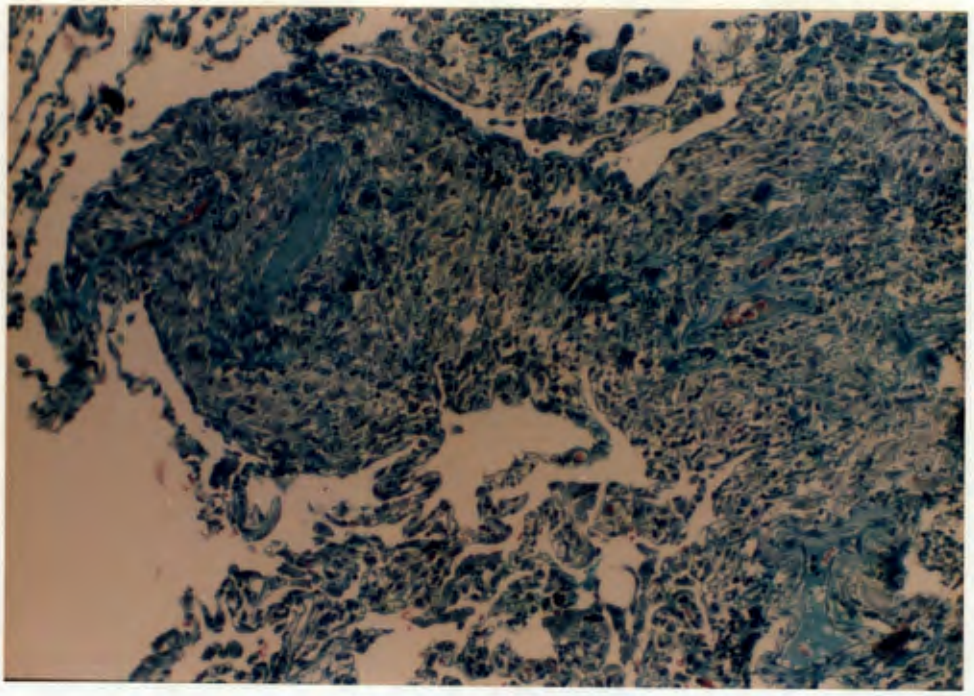


Plate 11: Masson's trichrome stain of mixed dust fibrosis showing abundant green staining collagen.

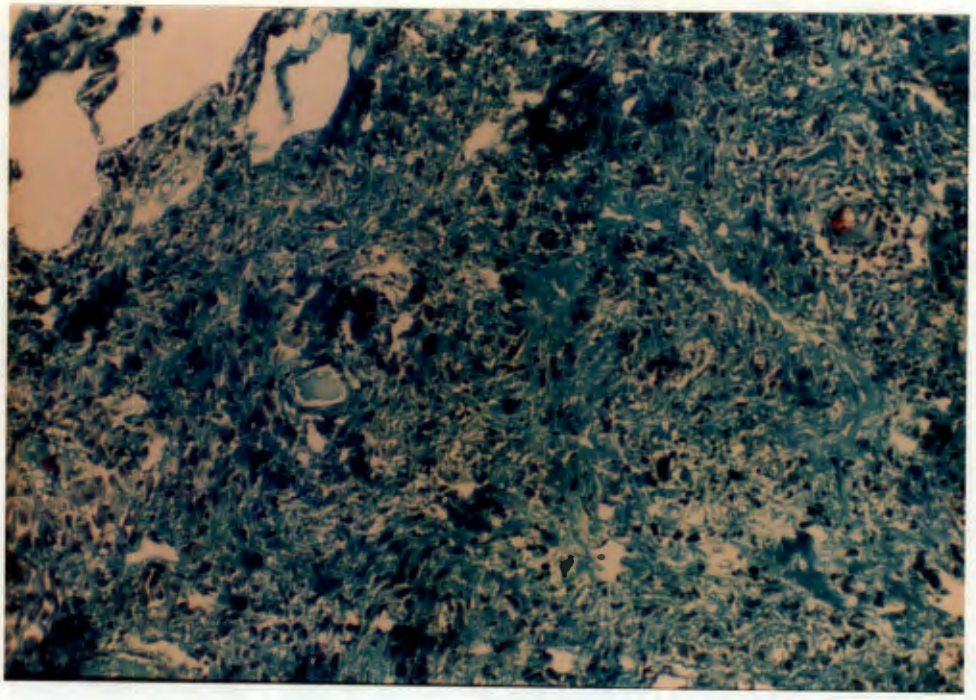
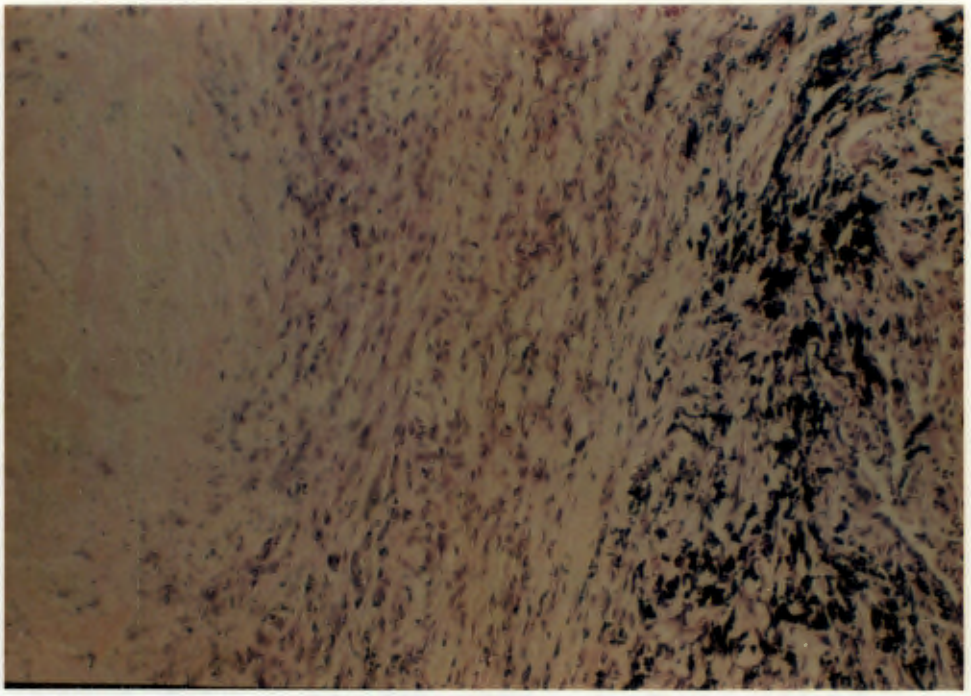


Plate 12: Mixed dust fibrosis showing pallisading fibroblasts and anthracotic pigment next to a whorled silicotic nodule.



3.6) CONTROL GROUP

The 7 Cape Town dwelling Xhosa females that made up the control group had a mean age of 41 years with a range of 23 to 64 years (cf 49 years with a range of 20 to 84 in the hut lung group). Six of the 7 (85,7%) were non smokers (cf 68% of the hut lung group).

A very mild degree of pigment deposition was found in a peribronchial, perivascular, septal and subpleural distribution in all the control patients. The degree of pigmentation was within the limits of that described as occurring in normal non occupationally exposed adults by the College of American Pathologists and was far less dense than that found in the patients with hut lung. Using polarised light refractile particles were observed in only 1 of the 7 control specimens.

3.7) PULMONARY PHYSIOLOGICAL FEATURES

The results of the individual values of the lung function tests that were performed on 22 of the patients with hut lung are shown in table 3. These values, except for the FEV1 to FVC ratio, are expressed as a percentage of the predicted values used by the Groote Schuur Hospital Respiratory Clinic (Cotes, 1979; Schoenberg et al, 1978; Grimby et al, 1963).

Table 3

LUNG FUNCTION TESTS EXPRESSED AS A PERCENTAGE OF PREDICTED VALUE

	FEV1	FVC	Ratio	T'LCO	KCO	TLC	RV	Assess/Comment
1)	57	113	43	64	90	172	296	AL
2)	66	119	47	54	68			AL/Smoker
3)	52	61	76	38	88	105	273	AL/PTB
4)	59	104	48	50	82			AL/PTB
5)	69	105	63					AL/PTB
6)	111	143	67	94	121	159	244	AL/PTB
7)	99	97	86	69	96	121	163	AL
8)	105	97	91					Normal
9)	105	109	79	58	75			Normal
10)	112	111	79	72	88			Normal/Smoker
11)	89	97	69	64	80	116	155	AL/Smoker
12)	65	61	89			80	117	RES/Smoker/PTB
13)	83	115	61	65	84	123	155	AL
14)	107	125	74	81	100	150	210	AL
15)	114	115	83	92	117			Normal
16)	146	147	82	64	83	151	175	Normal
17)	33	56	48	43	89			AL/PTB
18)	55	64	74	53	115	95	149	AL
19)	93	110	70	87	92	124	145	AL
20)	62	75	61					AL
21)	82	110	61			169	275	AL/Smoker/PTB
22)	87	134	63	66	91	188	218	AL

FEV1 = Forced expiratory volume in 1 second; FVC = Forced vital capacity; TLCO = Carbon monoxide gas transfer factor; KCO = gas transfer/litre lung volume; TLC = Total lung capacity; RV = Residual volume; AL = Airflow limitation; RES = Restriction; PTB = Probable previous tuberculosis.

Airflow limitatiom was observed in 73% (16/22) of the patients. Lung functions were within normal limits in 23% (5/22) while 4% (1/22) had evidence of restriction. The carbon monoxide transfer factor (T'LCO) was less than 80% of the predicted value in 76% (13/17) (Mean 65,5%; Range 38% - 94%) while the KCO was less than 80% of the predicted value in only 12% (2/17) of the patients.

Twenty seven percent (6/22) of the patients on whom lung function testing was performed were cigarette or pipe smokers but of the 16 patients with airflow limitation only 25% (4/16) were smokers while the remaining 75% of this group were non smokers.

However 27% (6/22) of the patients who had their lung function measured had evidence of previous pulmonary tuberculosis. One of these 6 patients had restricted lung functions while the remaining 5 (83%) showed evidence of airflow limitation. Of the remaining 16 patients who did not have evidence of previous tuberculosis 9 (56%) had airflow limitation while the remaining 7 (44%) had normal lung function. Airflow limitation was thus a commonly found feature of hut lung independent of any possible effect of smoking or previous tuberculosis.

3.8) **BRONCHOALVEOLAR LAVAGE FEATURES**

Two of the 6 patients who underwent bronchoalveolar lavage at the time of fibreoptic bronchoscopy were found to have secondary bacterial infections at the time and consequently had high polymorphonuclear leucocyte counts in the lavage fluid. The

remaining 4 unifected patients' lavage findings are recorded in Table 4:

Table 4

BRONCHOALVEOLAR LAVAGE RESULTS

Differential cell counts as % of total inflammatory cells

Total cells (Millions)	Lymph %	Polys %	Eos %	Mac Inorg %	Mac Cl %	GMac Inorg %	GMac Cl %
6,4	2,8	0,4	0,4	71,3	17,3	6,6	1,0
1,28	1,9	0	0	80,5	11,2	5,4	1,0
5,28	2,3	0,3	1,5	78,0	9,8	3,3	0
4,25	2,8	0	0,3	70,2	23,2	5,9	0,9

Lymph = Lymphocytes; Polys = Polymorphonuclear leucocytes; Eos = Eosinophils; Mac Inorg = Macrophages with inorganic inclusions; Mac Cl = Clear macrophages; GMac Inorg = Giant macrophages with inorganic inclusions; GMac Cl = Clear giant macrophages.

None of these patients was a smoker. Total cell counts were within normal limits (Mean 4,3 $x10^6$)as were differential counts for inflammatory cells i.e. lymphocytes, neutrophils, eosinophils and basophils. A mean of 75% of the alveolar macrophages (Range 70,2% - 80,5%) in the lavage specimens were heavily laden with inorganic inclusions.

The typical appearances of brochoalveolar lavage cells from patients with hut lung together with those from a normal non smoking control are illustrated in the following plates:

Plate 13: Bronchoalveolar lavage from normal non-smoker showing clear alveolar macrophages as well as a lymphocyte and a neutrophil.

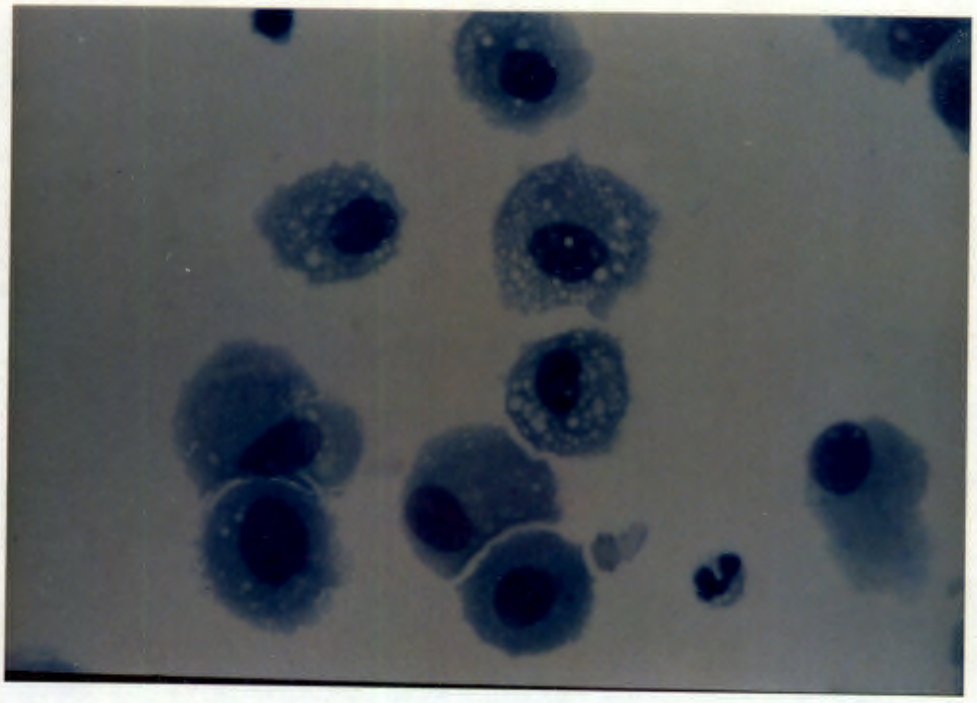


Plate 14: Bronchoalveolar lavage from patient with hut lung showing alveolar macrophages heavily laden with inorganic particles.

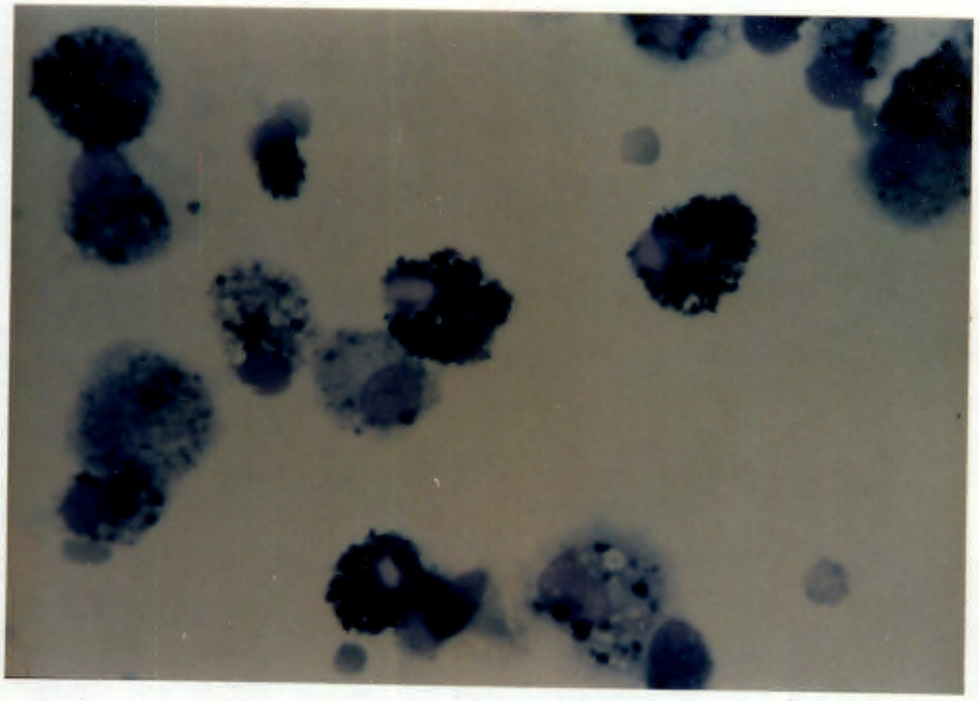
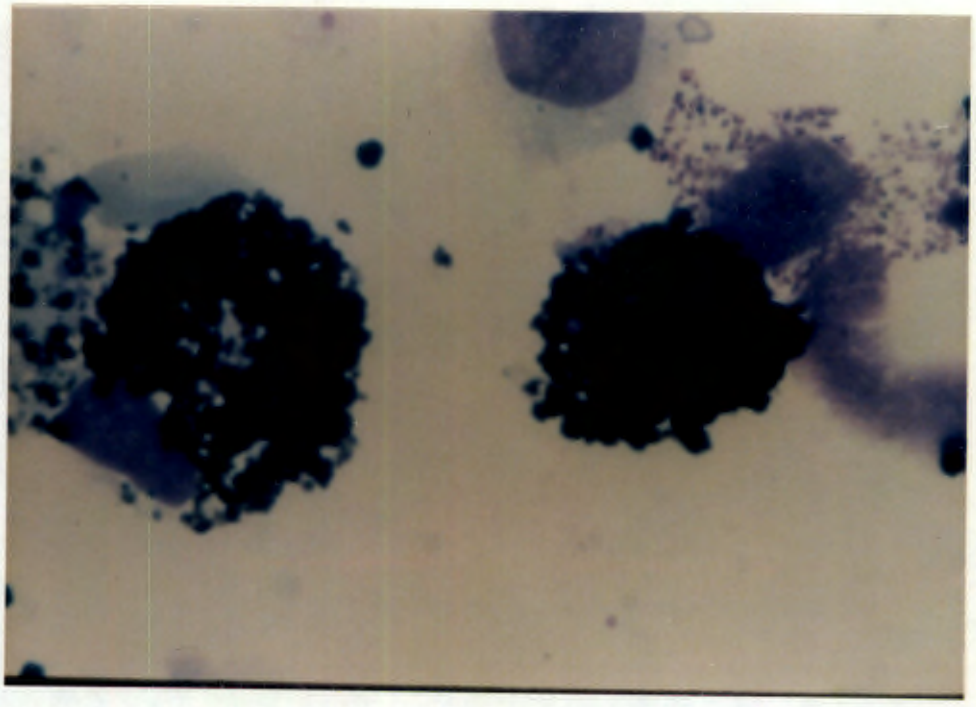


Plate 15: Alveolar macrophages heavily laden with inorganic inclusions.



3.9) BACTERIOLOGY

No bacteriological evidence for tuberculosis was found in any of the patients. In 5 patients commensal organisms were cultured from the bronchial brushings while in 2 patients upper respiratory tract organisms that were felt to be significant were cultured from the bronchial brushings and the lavage fluid. In one patient there was no record of any bacteriological examination. However this patient underwent 2 bronchoscopies at which a total of 8 transbronchial biopsies and 6 bronchial biopsies were taken, a lymph node biopsy and an open lung biopsy none of which showed any evidence of tuberculosis.

3.10) HAEMATOLOGY AND BIOCHEMISTRY

The results of the means and ranges of the blood counts, differential white cell counts and ESR's as well as the serum proteins are shown in table 5:

Table 5

HAEMATOLOGY

	Mean Values	Range
Haemoglobin (n=21)	- 12,9 g/l	10,8 - 14,6
White cell count (n=21)	- 7,8 x 10^9/l	4,3 - 17,4
Platelet count (n=16)	- 286 x 10^9/l	140 - 437
ESR (Westergren) (n=20)	- 42 mm/hr	5 - 150

Differential white cell count:

Polymorphonuclear leucocytes	- 56,7%	25 -83
Lymphocytes	- 30,5%	8 - 43
Monocytes	- 5,4%	2 - 17
Eosinophils	- 6,0%	0 - 26

(Mean absolute eosinophil count - 468 x 10^6/l)

SERUM PROTEINS

Total protein (n=16)	- 73,7 g/l	62 - 84
Albumin (n=16)	- 38,2 g/l	30 - 44

Two patients in this series had an elevated white cell count with a polymorphonuclear leucocytosis and were presumed to be secondarily infected even though no definite pathogenic organism was cultured at the time of bacteriological investigation. The moderately high mean absolute eosinophil count of 468 x 10^6 /l is almost certainly due to the high incidence of parasitic infestation found in rural Transkeians. All 3 patients in this series with significantly elevated eosinophil counts had worm ova in their stools.

PART 2

THE FIELD STUDY

4) INTRODUCTION AND GENERAL METHODS

A field study was undertaken in order to determine the factors in the home and lifestyle which might account for the pathology found in patients with hut lung. In particular respirable airborne contaminants were sought after and for this reason smoke and respirable dust levels during grinding were measured and quantitated. At the same time samples of the commonly used grinding rocks and ground maize produced were collected for analysis. Microbiological samples were also taken as part of the survey of the dust components in and around the villages.

The field study was undertaken in the Transkei as 88% of the patients with hut lung were rural Transkeian women. The Tsolo district was chosen because it was central, easily accesible from Umtata (the capital of the Transkei) and because it was felt that the local practices were representative of those used throughout the whole of the Transkei.

The investigators consisted of the author and an occupational hygienist from the National Centre For Occupational Health in Johannesburg. The aid of a guide and an interpreter from the

Umtata Chest Hospital's Pericarditis Ward was enlisted. The interpreter was a staff nurse who lived in Umtata with her husband and two children. She hailed from a rural village where her parents and most of the rest of her family still lived and whom she visited frequently. The guide was a rural Transkeian who lived in a village about 30 km outside Umtata and who spoke no English or Afrikaans. Both these ladies were very well informed about traditional domestic practices and personally participated when at their respective rural homes. The information gathered from discussion with the interpreter, guide and women of the villages visited as well as personal observation gave a clear idea of the lifestyle of the average rural Transkeian woman.

5) TRADITIONAL DOMESTIC PRACTICES

5.1) METHODS

The villages of Nomonde and Tyara which are about 50 kilometres apart were visited on 2 consecutive days. After obtaining permission from the village headman negotiations were made with the women of 2 average families from each of the villages to allow themselves and their huts to be monitored during the routine daily task of cooking on an open fire in an enclosed hut and the grinding of maize by means of traditional methods. In addition the process of making stamp mealies and maize beer or "Tswala" was observed.

5.2) **RESULTS**

It was observed that the average rural Transkeian family lives in a collection of 3 or more huts. One hut is used as a bedroom, one as a storeroom and one as a kitchen. All the huts are of similar design size and structure. A typical hut is round with a floor area of approximately $5m^2$. The walls are made of sun baked mud bricks and are approximately 2m high with a cone shaped thick grass thatch roof without any form of chimney incorporated in the design. Each hut has 1 or 2 very small windows that may or may not have window panes and a single door as its only sources of light, ventilation and an exhaust system for fire smoke and other fumes.

Plate 16: Typical collection of huts belonging to a family. Note the animal paddock to the right and the mud bricks in the foreground.

Fires are seldom made in the sleeping hut as most of the family members sleep on the floor and are aware of the risk of death from sleeping in a closed hut with a fire. This is presumably due to carbon monoxide poisoning. Fires for cooking purposes are generally only made in the kitchen hut with the door open. The fires are fuelled with wood, dried maize cobs and dried cow dung. A considerable amount of smoke is produced by the combustion of these biomass fuels. The atmospheric pollution is sometimes further contributed to by the smoking of pipes by some of the older women. Since there is no chimney the inside of the thatch roof becomes heavily impregnated with carbon and the other products of combustion.

Plate 17: Fire fuelled with wood, dried maize cobs and cow dung.

Plate 18: Elderly lady smoking traditional pipe during cooking.

Breakfast which consists of some form of maize meal preparation or "amabela" porridge (made from Kaffir corn) is always cooked inside with the cooking process and the concomitant smoke production lasting for approximately 1 hour. The main meal of the day which is prepared in the mid afternoon is usually cooked outside the kitchen hut and is only cooked inside if the weather is unfavourable.

Maize is the staple diet of the rural Transkeian population. Each

family has its own field that is cultivated with maize and various other crops. After ripening the maize kernels are allowed to dry on the cobs before being harvested and stored in the storage hut from where they are withdrawn as needed to supply the basic food requirements of the family throughout the ensuing year.

Plate 19: Dried maize cobs in storage hut. Note also the melons and a pumpkin on the far right.

The maize is used to make maize meal, samp and maize beer. In order to use the maize the kernels have to be stripped off the cob. This is done by hand after which the maize is either finely

ground into maize meal ("mealie meal") or stamped into"stamp mealies" for making samp.

Plate 20: Stripping maize kernels off the cobs. Note the smoke from the cooking fire.

Plate 21: The end product - loose maize kernels and empty cobs.

The process of dry grinding maize kernels into maize meal is carried out between two rocks. The mobile top grinding rock is about the size and shape of an oval loaf of bread and is held in the hands of the grinder who kneels over the large immovable base rock and rhythmically crushes the dry kernels into a fine powder of maize particles. It is during this process that a fine dust made up of particles of maize, grinding rock and other substances is released and may be inhaled by the grinder and anyone else who may be in the vicinity.

Plate 22: Sandstone grinding rock on top of base rock.

Plate 23: Maize grinder in action.

There are 2 major rock types found in the Transkei:

1) Sandstone which is a sedimentary rock and is the major rock constituent of the Transkei but has been eroded away from the surface through the ages because of its porosity and

2) Dolerite which is a hard wearing igneous rock that has been left behind where the sandstone has been eroded away.

Plate 24: Sandstone grinding rock producing coarse, crunchy maize meal.

Both of these rocks are used for grinding purposes. The base rock is usually dolerite while the top grinding rock is either dolerite or sandstone. Dolerite is a hard smooth surfaced rock that produces finely ground maize with minimal rock contamination. Sandstone is soft and porous and as a result crumbles easily during grinding thereby freeing significant amounts of rock particles that are incorporated into the ground maize meal. This makes the maize meal ground with sandstone coarser and crunchier than that ground with dolerite. This

feature is preferred by the majority of the consumers and sandstone grinding rocks are thus preferred. However sandstone grinding rocks are more difficult to find being limited to river beds which are far away from the villages that are built on small hills and thus dolerite is more commonly used.

Plate 25: Dolerite grinding rock producing finely ground maize meal. Note the hollowed out base rock.

The grinding process is carried out for about 45 minutes a day which is enough time to grind enough maize to supply the family's requirements for that day. All the women take their turn at grinding with the young girls starting to take up their duties from about the age of 10 years onwards. Allowing for absence at school it has been estimated that the average young woman aged 20 to 25 years has been occupied with grinding on a daily basis for at least 8 years (Palmer and Daynes, 1967). This would represent a cumulative exposure of 2190 hours. By extrapolation after 35

years of daily grinding (i.e. at age ±50 years) approximately 9581 hours of exposure would have been experienced (35 yrs x 45 mins x 365 days).

The process of stamping maize in order to produce stamp mealies from which samp is made is carried out in order to provide a variation in the presentation of the daily maize. The dry maize kernels are stamped with a pestle made from wood, metal or stone in a mortar made out of either a hollowed out tree trunk or a hollowed out rock (usually dolerite). Although small amounts of water are added during the process it remains a dry procedure giving off some dust. The stamped and fragmented maize kernels which end up about 1/4 the size of a whole maize kernel are then sifted in the wind to remove any loose particulate matter before being cooked as samp. The loose particles are collected on a mat and used as pig swill and thus nothing is wasted.

Plate 26: Metal pestle in wooden mortar made from a hollowed out tree trunk. Used in the production of stamp mealies.

Plate 27: Metal pestle and stone mortar hollowed out of the floor.

Plate 28: Stamp mealie production. Note the water seeping around the edges.

Plate 29: Sifting stamp mealies in the wind. Note the mat behind the basket for collecting the discarded particulate matter.

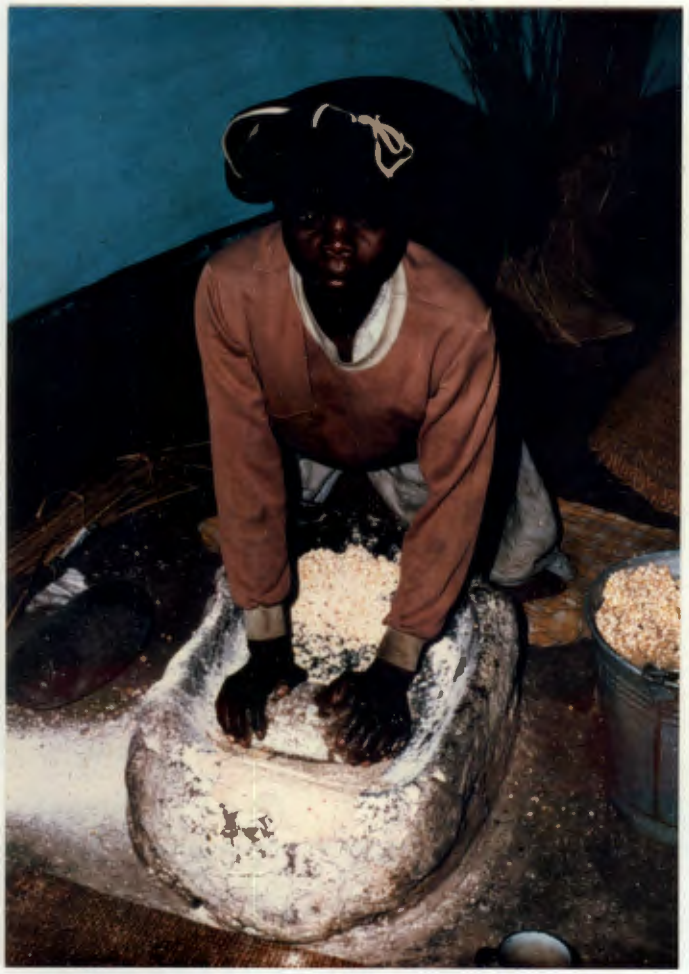


Plate 30: Making "Tswala".

The traditional maize beer or "Tswala" is made by wet grinding the maize kernels into a fine paste to which yeast and water are added in a 25 litre plastic drum after which fermentation is allowed to take place.

6) SMOKE LEVELS

6.1) METHODS

Smoke levels were measured with a MiniRAM smoke meter. Readings were taken during cooking on an open fire fuelled with maize cobs,wood and dried cow dung, during dry grinding of maize with the fire low and during no domestic activity with the fire just smouldering. A random carbon monoxide level was measured during the cooking process.

Plate 31: Measuring smoke levels during cooking with a MiniRAM smoke meter.

6.2) RESULTS

The results of the smoke levels measured are shown in table 6 and are expressed as the average smoke level in mg/m^3 for the sampling time indicated (number of minutes = number of readings taken):

Table 6

SMOKE LEVELS

	Average Smoke Level (mg/m^3)	Sampling Time (min/no of readings)
Cooking on fire made from maize cobs, wood and cow dung	30	20
Dry maize grinding with fire low	7,8	40
Fire smouldering with no domestic activity	0,6	32

During cooking on a full fire made from maize cobs, wood and dried cow dung the smoke produced caused intense conjunctival and mucosal irritation to the investigators but did not seem to affect the rural housewives.

A random carbon monoxide level measured during the most intense cooking process was 10 ppm. The National Institute for Occupational Safety and Health (NIOSH) threshold limit value (TLV) time-weighted average (TWA)(8 hour day, 40 hour working week) for carbon monoxide is 35 ppm (American Conference of Governmental Industrial Hygienists, 1986).

7) DUST LEVELS

7.1) METHODS

Dust particles with an aerodynamic diameter of up to 10 microns may be deposited within the alveolar region of the lungs and are referred to as respirable dust. The optimal alveolar deposition diameter is 2 to 5 microns and the majority of inhaled particles that reach the alveoli fall within this range. The most widely used air sampling devices are based on horizontal eltrutiators or cyclones and size selectively sample particles with an aerodynamic diameter of less than 7,1 microns according to the recommendations of the British Medical Research Council (Hamilton and Walton, 1961) and the 1959 Pneumoconiosis Conference in Johannesburg (Orenstein, 1960). Both the British and the United States federal dust regulations are based on the use of such an instrument (Morgan and Seaton, 1984). The Casella cyclone personal samplers used in this study are used by the South African mining industry and comply with the aforementioned international recommendations.

Respirable dust levels were measured with Casella cyclone personal samplers and pumps that were attached to the grinder by means of a belt and placed on a free standing tripod within 50 cm of the base rock. Measurements were taken during dry grinding with a sandstone grinding rock and with a dolerite grinding rock as well as during the preparation of stamp mealies.

Plate 32: Dust sampling during maize grinding.

Normal grinding lasts between 30 and 45 minutes. Since the sampling devices used were designed for use in industry and the mines where sampling is generally performed over periods of 4 to 8 hours it was felt that a longer period of grinding was required in order to obtain representative samples because of the technical limitations of the devices. The duration of measurements taken during maize grinding ranged from 40 to 160 minutes. Measurements of the longer periods of grinding were obtained by arranging each of 4 grinders to grind for 40 minutes in succession.

The respirable dust concentrations were calculated by dividing the weight of the dust by the volume of the air filtered. The quartz estimations were made by means of ashing the samples from

the cyclone sampler filters and then determining the weight of the residual inorganic matter which was shown to be quartz by means of x-ray diffraction. The percentage quartz was then calculated by dividing the weight of the quartz by the weight of the total respirable dust collected. The respirable quartz concentrations were then calculated by multiplying the percentage quartz and the total respirable dust concentrations.

The approximate empirical level of concentration of a potentially hazardous airborne dust which is unlikely to cause lung disease in a worker exposed to it over a period of a working life (approximately 35 years) is known as the threshold limit value (TLV). In the UK and the USA TLV's for the majority of airborne contaminants are related to the time that a worker is exposed to a particular risk. This is known as a time-weighted average (TWA) and refers to the average concentration of a substance to which a worker is exposed during an eight hour day and five day (40 hour) working week (Parkes, 1982). Threshold limit values of all hazardous substances are reviewed annually in the USA by the Committee on Threshold Standards of the American Conference of Governmental Industrial Hygienists (ACGIH) and the National Institute of Occupational Safety and Health (NIOSH) while other countries frequently issue their own standards.

7.2) **RESULTS**

The results of the respirable dust and quartz measurements as well as the calculated respirable dust and quartz concentrations

are shown in table 7. Typical values of respirable dust and quartz concentrations found on a controlled gold mine as well as the National Institute for Occupational Safety and Health in the USA and the World Health Organisation threshold limit values for respirable quartz are shown in table 8 for comparison (From unpublished work done for the Chamber of Mines by J.H.Quilliam in 1978; National Institute for Occupational Safety and Health, 1975; WHO, 1986). The SA gold mine values and the NIOSH and WHO TLV's are expressed as time-weighted averages (TWA's).

Table 7

DOMESTIC RESPIRABLE DUST AND QUARTZ CONCENTRATIONS

Grinding Rock	Time (Min)	Air Vol (m^3)	Dust Wt (mg)	Resp Dust Conc (mg/m^3)	% Qtz	Resp Qtz Conc (mg/m^3)
Sandstone						
-PS-	40	0,076	0,23	3,03	3,2	0,097
-SS-	60	0,122	0,71	5,82	3,2	0,186
Dolerite						
-PS-	158	0,324	0,85	2,62	0,9	0,024
-SS-	160	0,288	0,98	3,40	0,7	0,024
Stamping	50	0,098	0,43	4,39	<0,01	<0,004

PS = Personal Sampler (Attached to grinder)
SS = Standing Sampler (Placed on tripod)

Table 8

AVERAGE GOLD MINE RESPIRABLE DUST AND QUARTZ CONCENTRATIONS

(Time-Weighted Average Concentrations)

Work Type	Resp Dust Conc (mg/m^3)	% Qtz	Resp Qtz Conc (mg/m^3)
Rock Driller	0,844	19	0,160
Blaster	0,649	20	0,130
Winch Driver	0,611	13	0,079
Timber Support	0,532	11	0,059
Team Leader	0,649	5	0,032
Loco Driver	0,363	6	0,022

TLV.TWA (8 hr day, 40 hr week)	NIOSH (1975)	-	0,10
	WHO (1986)	-	0,04

8) ANALYSIS OF THE GRINDING ROCKS

8.1) METHODS

Analysis of the two types of grinding rocks was performed by means of x-ray diffraction of a crushed sample with a Phillips goniometer and by the preparation of thin sections for microscopic examination of the textural nature. A sample of known pure quartz was used as a control in order to increase the accuracy of the results.

8.2) RESULTS

X-ray diffraction of the sandstone grinding rock showed the presence of multiple quartz peaks. Thin section microscopic examination revealed a granular unmetamorphosed rock composed of approximately 100% quartz. The pore spaces were filled with detrital material and the rock was extensively weathered.

X-ray diffraction of the dolerite grinding rock showed peaks corresponding to constituents of plagioclase which is an igneous rock that contains little or no free silica. Thin section microscopy revealed a very fine grained rock composed of 60% plagioclase, 40% augite and < 1% oxides. The crystalline texture was closely knit together (i.e. no pore spaces) indicating a very resiliant rock. No quartz was present in the rock sample analysed.

9) ANALYSIS OF THE GROUND MAIZE

9.1) METHODS

A qualitative analysis of unashed specimens of maize ground with sandstone and dolerite as well as stamp mealies and finely ground wet maize (used for making beer) to detect quartz by x-ray diffraction was performed. A sample of pure quartz was diffracted as well to act as a control to improve the accuracy of the results and 0,02g NaCl was added to the stamp mealie sample as an internal standard. There was however a problem associated with resolving inorganic crystal peaks of low intensity in unashed specimens of maize because of the high background produced by the plant matter. Consequently low intensity peaks due to low concentrations of inorganic crystals were obscured and their presence or absence in low concentrations could not be confirmed.

9.2) RESULTS

The qualitative analysis of the maize ground with the sandstone grinding rock confirmed the presence of multiple peaks representing quartz that corresponded exactly with those seen on the crushed sandstone specimen. The maize ground with the dolerite grinding rock did not show any corresponding high intensity peaks of either quartz or plagioclase but did show

large numbers of low intensity peaks that merged with the background. These could represent an inorganic component amongst the organic matter (or background) but in much smaller quantities. The stamp mealies and wet ground maize showed no peaks other than that caused by the internal standard (NaCl).

10) ELECTRON MICROSCOPIC ANALYSIS OF THE DUST

10.1) METHODS

Dust samples were taken for electron microscopy during maize grinding with sandstone and dolerite as well as during stamp mealie production. The dust collected on the cyclone personal sampler heads was analysed from electron micrographs and by means of x-ray energy spectrometry.

10.2) RESULTS

Analysis of the EM samples revealed quartz particles, dolomite ($Ca.Mg(CO_3)_2$) and complex particles consisting of aluminium, calcium, chloride, iron, magnesium, potassium and silicon. These particles are illustrated in the following plates:

Plate 33: Electron micrograph of a quartz particle. (Bar represents 1 micron).

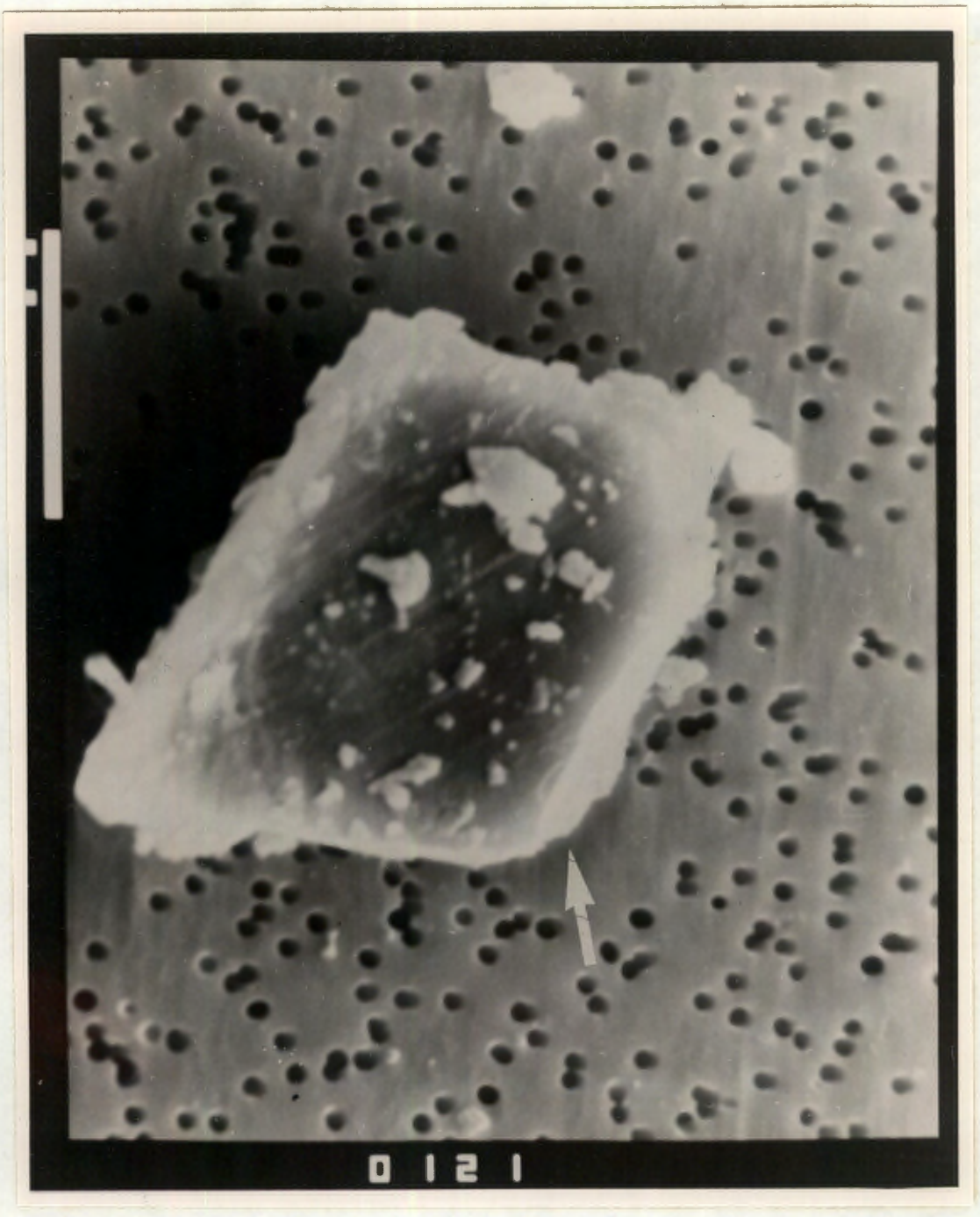


Plate 34: Electron micrograph of a particle of dolomite - $(Mg.Ca)CO_3$. (Bar represents 1 micron).

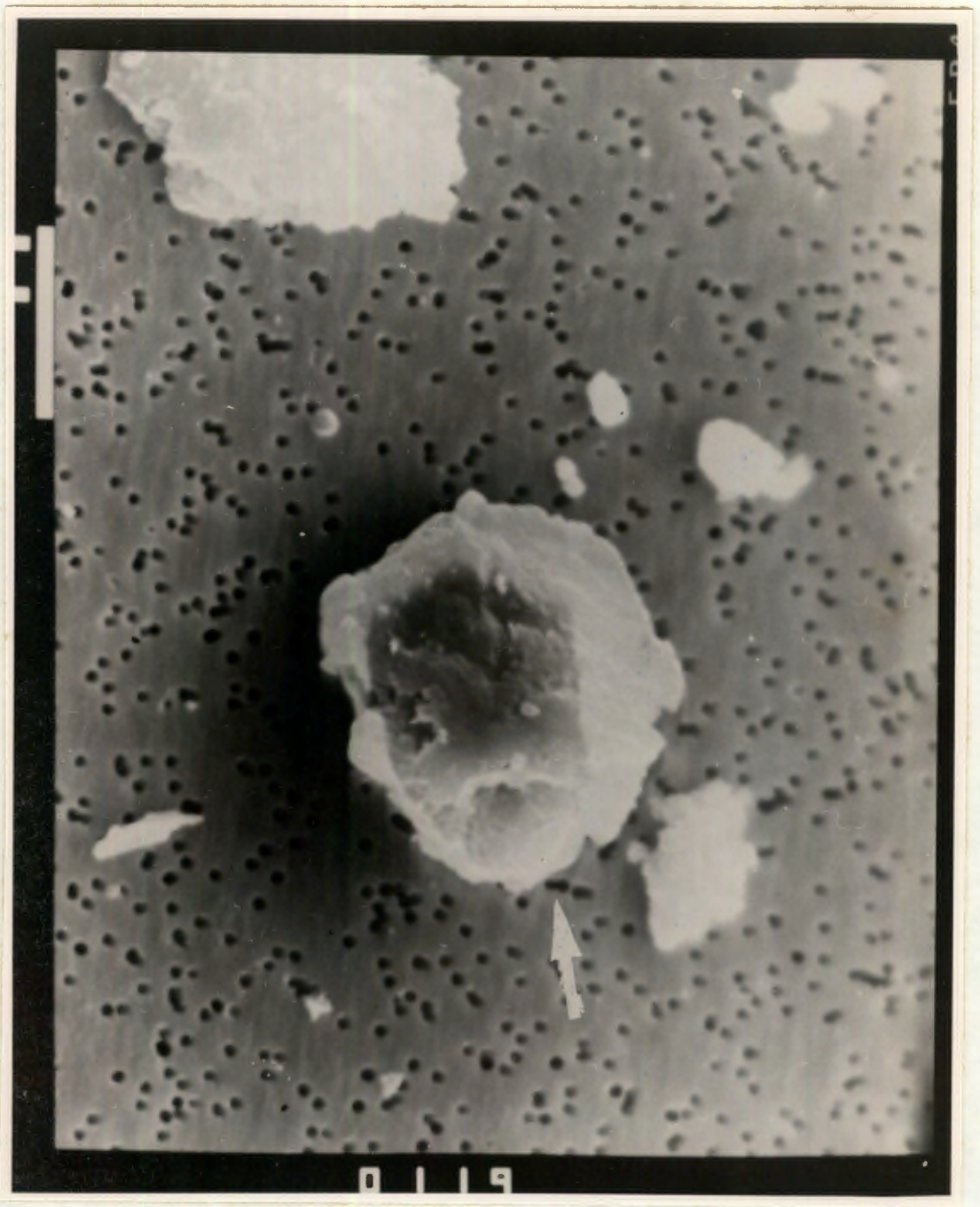


Plate 35: Electron micrograph of a complex particle isolated from maize dust containing Mg, Al, Si, Cl, K, Ca and Fe. (Bar represents 1 micron).

11) MICROBIOLOGICAL ANALYSIS OF AIR AND MAIZE SAMPLES

11.1) METHODS

Microbiological air sampling was done by using the gravimetric fall out method with standard settle plates for bacterial, mould and fungal culture. Samples of ground maize and stamp mealies were cultured for bacteria only. Standard microbiological techniques were used to identify all the growths obtained.

11.2) RESULTS

The results of the bacterial, fungal and yeast cultures isolated from the aerial settle plates are shown in table 9 while the results of the bacterial cultures of the ground maize and stamp mealie samples are shown in table 10:

Table 9

BACTERIA, MOULDS AND YEASTS ISOLATED FROM SETTLE PLATES

Bacteria	Moulds
Bacillus species	Alternaria
Enterobacter agglomerans	Aureobasidium
Enterobacter cloacae	Cephalosporium
Klebsiella pneumoniae	Chaetomium
Micrococcus varians	Cladosporium
Serratia marcescens	Curvularia
Serratia plymuthica	Drechlera
Staphylococcus aureus	Epicocum
Staphylococcus epidermidis	Fusarium
Staphylococcus hominis	Gliocladium
	Gliomastix
	Mucor
	Penicillium
Yeasts	Peyronellaea
	Phoma
Candida humicola	Rhizopus
Cryptococcus laurentii	Trichothecium
Trichosporon beigeli	Verticillium

Table 10

BACTERIA FROM GROUND MAIZE AND STAMP MEALIES

Ground Maize	Stamp Mealies
Enterobacter cloacae	Bacillus species
Micrococcus varians	Micrococcus varians
Micrococcus species	

The most predominant bacteria found were some of the Bacillus species and Enterobacter agglomerans while Drechlera and Fusarium were the commonest moulds. None of the host of microorganisms found in and around the huts were unexpected for a survey such as this.

12) DISCUSSION AND CONCLUSIONS

On the basis of this research project the entity of hut lung can be defined as a domestic pneumoconiosis acquired by rural women who practise primitive cooking methods. The typical patient is a mud hut dwelling rural Transkeian woman who is exposed to domestic smoke during cooking and grinds maize by means of the traditional methods described in section 5. It was also shown that this condition occurs in rural Namaqua women who do not grind maize but do cook on smoky wood fuelled stoves in poorly ventilated dwellings. Further sudies are required to identify this condition in other rural populations who practise similar primitive cooking techniques.

No males were included in this series. The reason for this is that rural Xhosa men who are found to have radiological changes of a pneumoconiosis almost invariably have a history of mining or industrial exposure. In addition traditional rural Xhosa males do not participate in any domestic cooking activities. During the course of this study three males from rural agricultural backgrounds with evidence of pneumoconiosis radiologically and histologically but with no history of occupational exposure were identified and may well represent a further extension of the spectrum.

Hut lung encompasses a wide clinical and radiological spectrum. The majority of patients have a benign form that appears to progress very slowly over many years of exposure and does not

cause any illness or disability. Most patients have no respiratory symptoms and have only mild radiological and pulmonary physiological abnormalities. Some patients are moderately to severely affected with more profound radiological and pulmonary physiological changes that cause them mild to moderate symptoms. Few may develop progressive massive fibrosis leading to respiratory failure with cor pulmonale and death.

The number of cases of hut lung occurring in the Transkei is not known but it can be reasonably assumed that most of these do not have any symptoms. In this series 48% of the patients had no respiratory symptoms. These patients had all presented to their doctors with other unrelated problems. Since radiologically milder forms of hut lung are indistinguishable from miliary tuberculosis patients in whom there were any suspicious features or in whom follow up might have been difficult were investigated fully. Many patients with clinically suspected hut lung who were seen at the Respiratory Clinic during the period of this study were not investigated further because they were well and could be followed up to confirm lack of progression and the absence of serious disease.

The degree of histological abnormality noted in this study is almost certainly underestimated due to the limitations of the sampling technique used in the majority of the patients i.e. transbronchial biopsies via a fibreoptic bronchoscope (Wall, Gaensler, Carrington and Hayes, 1981). The specimens obtained at

open lung biopsy and post mortem were the only two to show silicotic whorls. Considering the radiological changes noted it is highly probable that if larger specimens were available for analysis that more of the advanced histological changes occurring within the spectrum of hut lung would have been seen.

The pulmonary physiological changes described in section 3.7 confirm that a large proportion of patients have significant airflow limitation and reduced CO transfer factor. These changes are independent of the effect of cigarette and pipe smoking and previous tuberculosis, and are almost certainly largely due to excessive domestic smoke exposure since pure occupationally acquired silicosis does not cause such changes in lung function (Parkes, 1982).

The bronchoalveolar lavage findings have not been described previously and are of some value in distinguishing this condition from miliary tuberculosis in which high total cell counts and a predominance of either lymphocytes or neutrophils are found in the differential count (E.D. Bateman unpublished data). The high proportion of alveolar macrophages that are heavily laden with dense inorganic inclusions in patients with hut lung suggest excessive smoke exposure and are not a feature of miliary tuberculosis unless the patient has underlying hut lung as well. Bronchoalveolar lavage of heavy cigarette smokers may show high proportions of alveolar macrophages laden with inorganic inclusions but these are probably finer particles than those found in hut lung.

Tables 7 and 8 showed the results of the observed domestic respirable dust exposure together with time-weighted average (TWA) gold mine values as well as internationally accepted threshold limit values (TLV) for quartz exposure. These threshold limit values are considered to be levels below which disease is unlikely to occur during an 8 hour work day and a 40 hour working week over a 35 year working lifespan which would be equivalent to about 70000 hours of cumulative exposure. This represents approximately seven and a half times greater cumulative exposure than was calculated for the average rural maize grinder over 35 years of daily exposure (9581 hours).

The levels of respirable dust concentrations to which rural maize grinders are exposed for 45 minutes a day during grinding were shown to be between 3 and 10 times those to which gold miners are exposed for 8 hours a day. Similarily the respirable quartz levels during sandstone grinding (ranging from 0,097 to 0,186 mg/m^3 with an average value of 0,142 mg/m^3) were moderately greater than the average gold mine figure of 0,08 mg/m^3 (ranging from 0,022 to 0,160 mg/m^3) and only slightly greater than the NIOSH TLV of 0,1 mg/m^3 but were well below these values during dolerite grinding (average value of 0,024 mg/m^3) and stamping ($<0,004$ mg/m^3).

In order to make a fair comparison between a rural maize grinder's respirable dust and quartz exposure to that of a typical SA gold miner and the NIOSH and WHO TLV's an equivalent TWA for a maize grinder's exposure over the equivalent of a

miner's week (40 hours) must be calculated. To convert the results observed in the maize grinders to equivalent TWA values the maize grinder values should be divided by 7,5 (40 hours versus 5,25 hours weekly exposure). This estimates the approximate cumulative weekly exposure. Table 11 shows the calculated comparable equivalent TWA values of respirable dust and quartz exposure in the maize grinders together with some of the typical gold miners exposure values and the NIOSH and WHO recommended TLV's.

Table 11

EQUIVALENT TIME-WEIGHTED AVERAGE RESPIRABLE DUST AND QUARTZ CONCENTRATIONS IN MAIZE GRINDERS AND SA GOLD MINERS

	Resp Dust Conc (mg/m^3)	Resp Quartz Conc (mg/m^3)
Sandstone Grinder PS	0,404	0,013
SS	0,776	0,023
Dolerite Grinder PS	0,349	0,0032
SS	0,453	0,0032
Rock Driller	0,844	0,160
Blaster	0,649	0,130
Team Leader	0,649	0,032
Loco Driver	0,363	0,022
NIOSH (1975) TLV.TWA		0,10
WHO (1986) TLV.TWA		0,04

PS = Personal Sampler (Attached to grinder)
SS = Standing Sampler (Placed on tripod)

The calculations derived in table 11, being TWA's which allow for cumulative duration and level of exposure, thus suggest that even the worst exposed maize grinder has a 7 times less cumulative risk of developing silicosis than does the worst exposed gold miner. The fact that the three Namaqua ladies in whom the criteria required to make a diagnosis of hut lung were fulfilled did not grind maize and presumably were thus not exposed to significant quantities of quartz, confirms that the inhalation of respirable quartz dust alone is not responsible for the changes that occur. Exposure to intense domestic smoke (shown in section 6) and non-quartz containing dust without obvious fibrogenic potential must also be very important aetiologically with the presence of small amounts of quartz probably resulting in an enhanced fibrogenic effect in some patients.

The evidence supporting this hypothesis comes from animal studies and observations in man. In animal studies over periods of chronic exposure it has been shown that the addition of small amounts of quartz modifies the effect of non-fibrogenic dust exposure resulting in a greater fibrogenic response (Martin et al, 1972). In man mixed dust fibrosis is known to be caused by crystalline silica (which is fibrogenic and occurs most commonly as quartz) together with other dusts such as carbon, iron, kaolinite and feldspars being inhaled simultaneously during one occupational process. It is known that when the proportion of free silica to non-fibrogenic dust inhaled is low the typical nodular lesions of silicosis either do not occur or are infrequent, and irregular fibrotic lesions are produced. As the

quartz content of the inhaled dust increases so does the fibrogenic capacity of that dust (Parkes, 1982).

The lesions of occupationally acquired mixed dust fibrosis are identical to those that were found in 28% of the patients with hut lung in this series. This would support a mixed dust aetiology of hut lung and explain some of the spectrum of changes found. Sandstone grinders with their greater degree of exposure to both quartz and non-quartz containing dust should theoretically be at greater risk of developing hut lung of a greater degree of severity than dolerite grinders. This remains to be confirmed in future studies of this condition.

The variable duration and intensity of exposure to domestic smoke and dust experienced by patients who develop hut lung further explain some of the spectrum. In the occupational situation the duration of exposure relates to the degree of abnormality found. This relationship was not examined in this study but it would seem logical to apply the same principle to the domestic situation. The early age of exposure often as early as the neonatal period from being fastened to the mothers back while she cooks and grinds maize may be important in determining susceptibility to later abnormalities. Future studies are necessary to assess these speculations.

The precise role of previous tuberculosis in the spectrum of hut lung as well as the effect of underlying hut lung on the

development of future tuberculosis remains to be fully defined. The relationship between occupational silicosis and a predisposition to the development of pulmonary tuberculosis has been well established (Ziskind, Jones and Weill, 1976; Parkes, 1982; Morgan and Seaton, 1984). This occurs because free crystalline silica is extremely toxic to the pulmonary macrophages that make up the lung's major defence against Mycobacterial infection. The data in section 3.3 shows that 28% of the patients with hut lung in this series had evidence for previous tuberculous disease that might have contibuted to some of the abnormalities found. The Transkei and Ciskei Research Society survey in 1972 (Van Der Walt et al, 1983) noted the incidence of pulmonary tuberculosis to be 8,8% in males and 7,2% in females in the Transkei and Ciskei. It is speculated that patients with hut lung may have a higher incidence of pulmonary tuberculosis than would otherwise be expected and that this may be accounted for at least partially by the inhalation of respirable quartz particles as in the occupational situation. A large epidemiological survey is required to accurately separate the effects of the two conditions and their relationship to one another.

It can be concluded that the aetiology of hut lung is multifactorial with exposure to both non-quartz and quartz containing dust as well as smoke particles from biomass fuelled fires all contributing significantly and that it is not a pure form of silicosis as was previously thought. The precise role played by previous tuberculosis and other susceptibility factors

in the aetiology of hut lung still needs to be clarified as well as the effect of the various constituents of the non-quartz containing respirable dusts that are inhaled.

In the early 1970's attempted preventive measures in the Transkei were recommended by Daynes. Rural women were made aware of this condition via the TB health visitors and an attempt was made to encourage the local shopkeepers of each village and the more affluent villagers to purchase simple cheap mechanical hand grinders for communal use and thereby decrease their exposure to traditional maize grinding. On questioning the interpreter and guide about this they confirmed having vague memories of such a campaign which they felt had been largely unsuccessful and indeed the few shops visited during the field trip revealed no evidence of such devices. A further discouragement to this preventive campaign is the fact that the crunchier form of maize meal produced by the traditional grinding methods is a feature preferred by the majority of the consumers as was outlined in section 5.2. Since it has been shown that the dense smoke emitted by the biomass fuelled fires in enclosed huts is a highly significant causative factor preventive campaigns should rather focus on the establishment of simple ventilation systems for use as chimneys in the cooking huts. Future attempts at preventing the development of hut lung are challenges facing the health authorities in the rural areas of not only the Transkei but of all the developing parts of the world.

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