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HISTORICAL RESEARCH REPORT

Research Report TM/85/03
1985

Studies of the Scottish oil shale industry. Seaton A, ed Vol.2 Shale workers' pneumoconiosis and skin conditions: epidemiological surveys of surviving ex-shale workers Final report on US Department of Energy Project DE-ACO2-82ER60036

Louw SJ, Cowie H, Seaton A

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Editor: Dr. A. Seaton

VOLUME 2

PNEUMOCONIOSIS AND SKIN CONDITIONS

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A. Seaton

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STUDIES OF THE SCOTTISH OIL SHALE INDUSTRY

FINAL REPORT TO U.S. DEPARTMENT OF ENERGY
ON RESEARCH PROJECT NO. DE-AC02-82ER60036

Editor : Dr. A. Seaton

VOLUME 2

SHALE WORKERS' PNEUMOCONIOSIS AND SKIN CONDITIONS: EPIDEMIOLOGICAL SURVEYS OF SURVIVING EX-SHALE WORKERS

by

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SHALE SURVIVORS STUDY

CHAPTER 1

INTRODUCTION

The world's largest and richest reserves of oil shale occur in the United States and it is anticipated that major development of these reserves will take place over the next decade.[1] Because of the small size of the operation to date and the mobility of the workforce between a number of dusty industries, it has not proved possible to obtain reliable data on the health risks to the workforce that such a development might entail.[2] While the risks of accidents, explosions and local pollution may reasonably be estimated by analogy with similar industries, potential specific hazards of shale oil production itself, such as pneumoconiosis and lung and skin cancer, can only be assessed by study of an established shale industry.

A shale oil industry started in West Lothian, a district of Scotland close to Edinburgh, in the 1850s. The workforce was composed of local men who lived in small village communities. The other major industry of West Lothian was coalmining, but there was little interchange of workforce between these two industries. The industry reached its peak in 1913, when some 10 000 workers were employed. Thereafter it underwent a decline, temporarily interrupted during the second World War, and finally closed down in 1962. Apart from achieving distinction as the first source of automobile fuel (known in Britain as <u>petro</u>leum because of its derivation from <u>rock</u>), the industry also achieved notoriety on account of the tendency of some of its workers to develop epithelial tumours, especially on their arms and scrota, described by Bell in 1876.[3] Such tumours were also described in workers in the Lancashire cotton industry, which used shale oils for lubricating purposes.[4] This early recognition of an occupational cancer, second in time only to Pott's description in 1775 of scrotal cancer in chimney sweeps,[5] led to an important series of studies of skin conditions in the oil shale industry by Scott.[6] This doctor, having made a systematic investigation of these diseases, instituted a

number of preventive measures, chief among which were the introduction of baths and instruction in hygiene, together with a system of medical surveillance which resulted in a considerable decrease in the incidence of skin cancer as recorded in the annual reports of the Chief Inspector of Factories.

Apart from this history of carcinogenesis, the Scottish shale oil industry seems to have been regarded as relatively healthy, although there is no doubt that it was a considerable polluter of the local environment. One reference has been found to the characteristic cough of retort men, though in connection with arbitration proceedings,[7] but no investigation of respiratory conditions of shale workers appears to have been made until the present study. Likewise, no mortality studies of workers in the industry have previously been carried out.

In 1981, an account was published of four ex-shale miners with progressive massive fibrosis (complicated pneumoconiosis).[8] All had worked throughout their lives in shale mines and had reached advanced age. Two had developed, in addition to their pneumoconiosis, peripheral squamous lung cancers. This demonstration of pneumoconiosis in shale miners, coupled with the knowledge that men were also exposed to shale dust at the crushers and retorts, led to the formulation of the plan of the present research. This was made possible by finding records of the Scottish Oils Ltd 1950 Provident Fund, which allowed identification of all employees in the shale industry from 1950 until its closure. The Fund application forms also gave details of employees' occupational histories and sufficient information to allow attempts at tracing them and determining their vital status. This volume describes the use of this Provident Fund form in identifying ex-shale workers and subsequent studies aimed at determining the prevalence and respiratory effects of pneumoconiosis and the prevalence of skin disease amongst them.

CHAPTER 2
AIMS OF THE INVESTIGATION

In accordance with the research contract between the IOM and the US Department of Energy, surveys of the study population were planned in order to meet the following aims:

(a) to determine the prevalence of shale workers' pneumoconiosis among men who worked in different job categories (as an index of relative dust exposure), with control comparisons;

(b) to study the nature of physiological impairment of men with shale workers' pneumoconiosis, in comparison with other shale workers with similar job histories;

(c) to compare the prevalence of benign and malignant skin tumours among ex-shale workers with that of a control population; (if relevant, the prevalence of tumours in specific job categories was to have been determined);

(d) to obtain information on the smoking habits of the study population.

CHAPTER 3
METHODS

3.1 Definition of Study Population

The definition of the study population was: all male members of the '1950 Scottish Oils Ltd. Provident Fund' who agreed to participate in the study.

The research protocol made provision for the possibility of a very high response rate, in which case a random sample of 2 000 men, stratified by age, was to be selected for study. Since fewer than 2 000 men agreed to participate in the study, it was decided to include all respondents living in the UK in the postal surveys; all respondents living in West Lothian were included in the radiographic survey.

3.1.1 The 1950 Provident Fund Scheme of Scottish Oils Ltd. (The Fund).

The study was made feasible by the fact that virtually all workers in the Scottish shale industry from 1950 onwards joined a Provident Fund. The present administrators of the Fund are the pay office staff of the British Petroleum Company's Refinery at Grangemouth, Scotland. The Fund is described in detail in Appendix 1; the following are those attributes that have a bearing on its adoption as a study-group definition:

(a) The Fund included all Scottish workers who were engaged in the oil-shale industry (The Industry) for more than 2 years during the period 1948 to 1962.

(b) Upon applying for membership to the Fund, men were required to complete a Provident Fund Application

Form (P-Form), on which their job histories were recorded. This information was carefully corroborated with the existing company records and errors were corrected by the Fund administrators. (See Section 3.1.2 for further details).

(c) The Fund was available only to manual workers and craftsmen. Thus "staff" workers (clerks and managerial staff) and supervisors (works-foremen) were not eligible, unless they were industrial workers who had been promoted to staff or supervisory positions.

(d) Some "non-shale" workers were members of the Fund. Most of these worked at the BP Refinery (Grangemouth) which has never processed shale oil; some also worked at a detergent-soap factory after the closure of the shale industry in 1962. These men were included in the data-gathering stages of the study and subjected to procedures identical to those defined in (a) above. At analysis, however, both groups comprised a "control group" for the skin study; the former was a non-dust-exposed control group for the radiological survey.

(e) The P-Forms for the holders of 289 Provident numbers could not be located. It should be noted that men who left the industry temporarily were often given a new number when rejoining. Their former number would then become redundant. It is presumed that the majority of these "missing" P-Forms belonged to such redundant numbers

(f) Although women were equally eligible for Fund membership, they were excluded from the study. Their inclusion would have complicated interpretation

of radiographic and spirometric data. There were 264 female Fund members.

3.1.2 The Provident Fund Application Forms (P-Forms)

The P-Form was the manuscript which represented an individual's successful application for membership of the Fund. Only men whose P-Forms were available (see 3.1.1(e) above) were included in the study. These forms provided essential information for the study, since they contained the members' identifying details (including full names and dates of birth), as well as a detailed record of jobs that were held in the industry prior to joining the Fund. The first stage of the survey was the manual transcription of all pertinent details onto a form resembling the original P-Forms. These transcription forms were adapted (see Appendix II) to allow the inclusion of additional information, such as date of death, place of death, last known address, date of leaving the industry and last occupation, which were extracted from other records held in men's personal files. Checks were made to ensure that the transcription by the clerks was accurate.

3.2 Tracing and Contact Procedures

In total, the P-Forms of 6 359 men were available for the study. In organising the tracing procedures, the first objective was to determine, with the greatest certainty practicable, the vital status of each man. This was required for two reasons: (a) it was desirable to avoid causing unnecessary distress to relatives by inadvertently sending letters to the addresses of deceased men and (b) the names of deceased men were to be used in the concurrent mortality study. The second objective was to obtain the current addresses of surviving members of the Fund. The third objective was to make contact with these men to

invite them to participate in the surveys. In the main, the procedures that were used to determine vital status also provided us with the current addresses of survivors. Four methods were used, as follows:

3.2.1 Fund Administration Records

These records provided information regarding the vital status of 2 079 men. Of these, 1 571 were deceased and 508 were recent or current employees at the BP Refinery and their addresses were thus easily obtained.

The remainder of the study group (4 280 men) were traced using the following steps:

3.2.2 Local Enquiry and Electoral Rolls

The tracing, by local enquiry, of men whose addresses were obtained from the Fund Administration records, was undertaken in two stages: (a) by checking their names against the addresses appearing in the Electoral Rolls and (b) by interviewing key persons in the community.

The Electoral Rolls are arranged according to the residential addresses of voters, so that the lay-out is in street-order of constituencies. Using the last known address of each man (obtained from the Fund records), the names of the current residents of each address were examined. If a name corresponding with that on the relevant P-Form was found to be registered as a voter, then this was taken as sufficient evidence of the man's survival to permit the forwarding of an invitation to participate in the survey. The Electoral Rolls of 1980 were used initially; during the course of the study the 1982 revision became available.

The names of those men who could not be traced by means of the Electoral Rolls were taken to "key" persons in the communities to obtain further information. This stage of the tracing procedure was feasible because many of the villages in the shale area are small, closely-knit communities. The names of surviving men whose addresses were obtained by such local enquiries were again checked against the Electoral Rolls and, if the information could be corroborated, invitations were sent. The names of men who failed to respond to the invitations were passed on to DHSS (see below).

The survival of 30 men who failed to respond to our letters was confirmed by visits to their homes. All of these refused to participate in the study. This exercise served to confirm the validity of our tracing procedure, but as a tracing method, it was too expensive to adopt on a general scale. An attempt was also made to trace men by using telephone directories, but this method gave poor results. In six instances men were said to be in hospital at the time of the local enquiries; none of these was able to participate in the study.

3.2.3 The Department of Health and Social Security (DHSS)

The DHSS was an effective means of contacting men (and identifying deceased men) through their Letter Forwarding Service. The service is available to approved medical researchers and consists of the forwarding, on behalf of the investigator, of a sealed envelope to the index subject at the last address known to the DHSS. The address is not disclosed to the enquirer and it is up to the addressee to return his address to the enquirer if he wishes to do so.

The DHSS were able to forward 1 298 letters on our behalf, including letters to some men who did not respond to

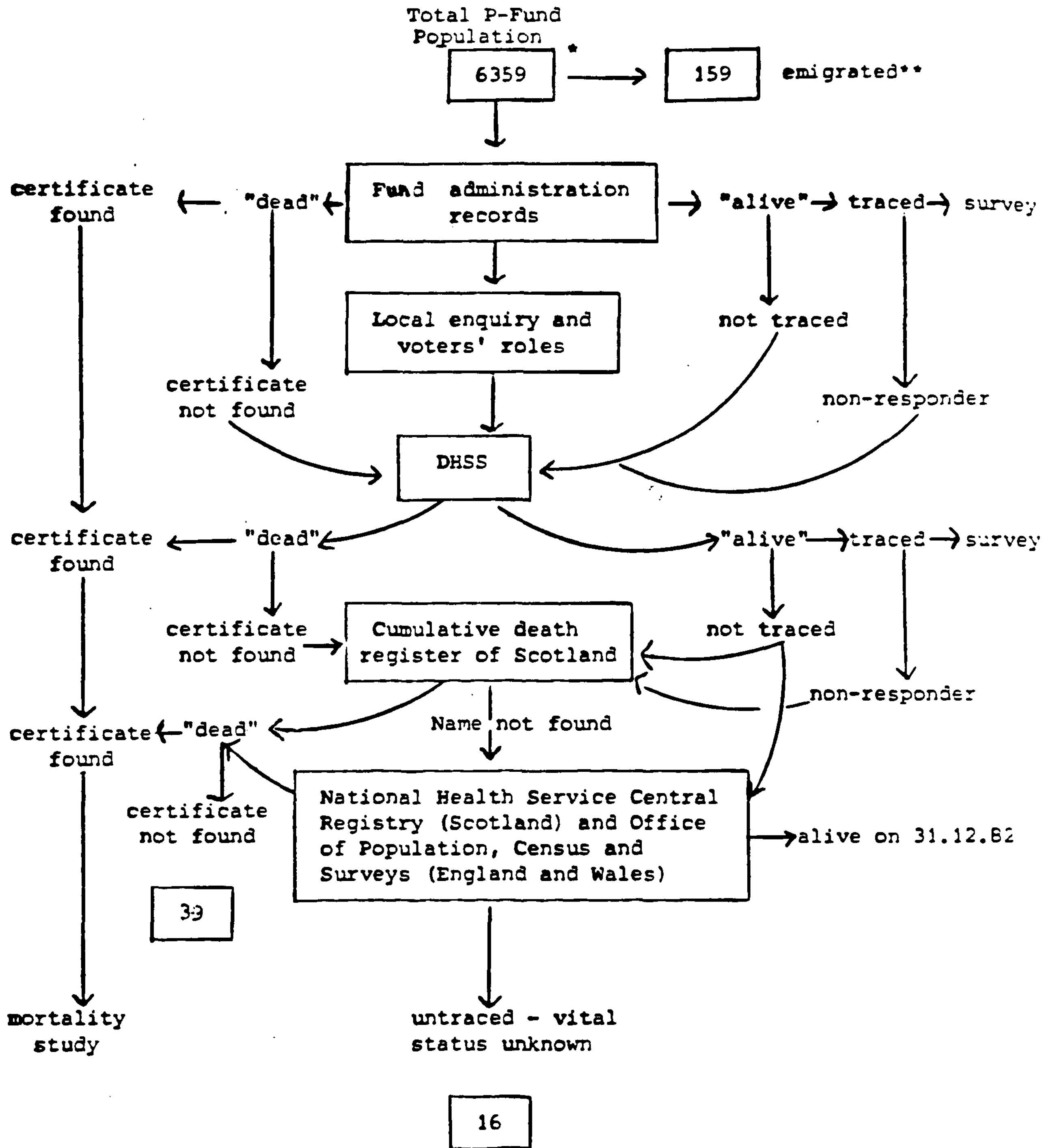
letters sent to addresses previously available to us. The dates of death of 956 men were also provided, some in confirmation of previously obtained information. Six hundred and seven men could not be traced by DHSS, and were classified into the following categories:

(i) no later address than the one provided by the IOM;
(ii) no current address - no recent activity in the DHSS account;
(iii) letter returned as "undeliverable" by the Post Office;
(iv) subject could not be identified by the DHSS;
(v) subject had emigrated and DHSS lacked evidence of his return.

Further intensive searches were undertaken to confirm the vital status of these men (as well as all men who had not responded to our letters) for the purposes of the concurrent mortality study, and the procedures are described in Appendix 3; they were time-consuming, requiring an additional 8 months to complete. The surveys were, however, confined to men traced as the result of the procedures described above, since the additional sources provided only vital status information and not current addresses. The tracing procedure as a whole is outlined in Fig. 3.1.

3.3 Invitations and Letters

Once the current addresses of men had been confirmed, letters were sent to invite them to participate in the surveys. These invitations were sent in batches as each of the cycles in the tracing procedure was completed. The wording of the invitation was progressively improved in response to suggestions and enquiries. Men who were traced by means of the procedures outlined in 3.2.1 and



* Because a large proportion of records were checked against more than one record system, the actual numbers of records have not been included in the rest of the breakdown.

** These men were found to have left the UK - 23 of them were known to have died abroad.

Figure 3.1: Tracing procedures of Provident Fund members

3.2.2 who failed to respond to the first invitation were sent a reminder by recorded delivery post. Reminders could not be sent to men whose tracing depended on the DHSS (see Para. 3.2.3).

3.4 Data Collection

General Outline

In order to meet the aims of the study seven discrete classes of information were required:

(a) Identification details of men and dates of birth. These were available on the P-Forms.

(b) Occupational histories. These were obtained by a clerk at the X-ray survey and, for the men who answered skin questionnaires but did not attend the X-ray survey, the P-Form histories were used.

(c) Chest radiographs. These were taken in the IOM's mobile X-ray unit. Using a standardised procedure, radiographs were taken of ex-shale workers and a group of petroleum oil refinery workers. All radiographs were read by 6 para-medical readers and 4 medically-qualified readers.

(d) Lung physiology tests. These were done in the IOM's mobile physiology laboratory. Using standardised procedures, the lung functions of a group of ex-shale workers with pneumoconiosis and a group without pneumoconiosis were obtained. Members of the two groups were selected in such a way that they had similar occupational histories and age distributions.

(e) Respiratory symptoms questionnaire. This was administered by an experienced clerk to all men attending the lung physiology survey.

(f) Postal smoking questionnaires. These were sent to all members of the Fund who agreed to participate in the questionnaire survey. The data were used in the interpretation of the findings in (c) and (d) above.

(g) Postal dermatology questionnaires. These were also sent to all members of the Provident Fund who agreed to participate in the questionnaire survey. A similar questionnaire was sent to ex-colliery workers.

The methods used to obtain these different classes of data were as follows:

3.4.1 Occupational Histories

Sources

The occupational histories were obtained from two sources: (a) the histories available on the P-Forms (the sources of which are described in Section 3.1.2) and, (b) the histories obtained by a clerk during the X-ray survey.

(a) P-Form occupational histories

These histories had the advantages of (i) great accuracy with regard to both the places of work and all relevant dates (see Appendix 1, and Appendix 4) and (ii) having been compiled at the time when the men joined the Fund, clearly quite independently of the present surveys. Their usefulness was, however, limited by three disadvantages: (i) the histories were recorded only up to the day that the men joined

the Fund. Thereafter no work-history was normally recorded apart from the "last occupation" at the time of resignation or retirement (ii) the job titles tended to be vague in many instances; for example, "miner" - a vague term which does not indicate whether the man was a face-worker or a surface-worker. (iii) they did not record any of the men's activities outside the shale industry. Thus, no information regarding their jobs before joining the industry, or during breaks in service, or during the period after leaving the industry and the present surveys was available.

(b) <u>Clerk-obtained occupational histories</u>

These histories were obtained by a clerk in the form of a narrative chronological history. The clerk concerned is the full-time "industrial history clerk" of the IOM. He underwent training, including measurements of reproducibility, in the method of taking industrial histories when he joined the IOM about ten years ago. Prior to the present survey he was familiarised with the various processes in the shale industry and provided with a description of the names of the various jobs which had been recorded in a job-name dictionary. A copy of the P-Form history of each man was available to him, but, in general, the clerk's histories were independently obtained. He was also given a list of the commonly used job-names that were vague and instructed to obtain detailed information on these whenever they arose. At the end of each interview, he compared the P-Form history with his own and resolved contradictions (if any) by further discussion with the man concerned.

The advantage of the clerk-obtained history was that it resolved several difficulties intrinsic to the P-Form histories. This history was complete (no gaps), specific (no vague terms) and also accounted for all activities outside the industry (or BP). The principal disadvantage was that it relied on the accuracy of the men's memories. The availability of the P-Form histories counteracted this disadvantage, especially since the P-Form was most comprehensive in the earlier part of the men's work in the industry.

Clearly, the clerk-obtained history was available only for those men who attended the X-ray survey. Thus, for the additional 435 men who answered questionnaires, only the P-Form occupational histories were available. Consideration was given to the possibility of obtaining a more detailed history from these men by means of a postal occupational history. However, in a pilot study designed to assess the feasibility of using a self-administered questionnaire, it was found to give rise to too many errors, omissions and contradictions to justify its formal adoption.

Classification and Coding of Occupational Histories

The classification and coding of the occupational histories consisted of two separate tasks: (a) the compilation of a job-name dictionary and the grouping together of jobs according to sites of work; and (b) the stratification of groups of jobs according to a hierarchy of severity of dust and oil exposure.

(a) Job-name dictionary and job classification

A dictionary, containing the approximately 1 765 job names that were used throughout the shale industry was compiled, using a computer-assisted listing of

job names appearing on the P-Forms. The job titles were then grouped into 28 categories according to the sites of work within the industry. Certain commonly-used terms were vague insofar as they lacked specificity and could not readily be placed in one or other job category. These were therefore given individual codes to allow a subsequent descriptive analysis. At the mines, these terms were "general workers", "labourer", "miner", "pumpsman" and "oncost worker"; at retort works the terms were "labourer", "cleaner", "oncost worker", "general worker", "shale workers" and "trainee".

(b) Hierarchy of job categories according to exposure to dust

Enquiries at the relevant government authorities and a review of the literature (including the Index of documents held in the archives of BP Refinery, Grangemouth) revealed no evidence that systematic dust measurements had ever been made in the shale industry.

Dust exposure occurred at three sites in the industry, i.e., the mines, the retort works and the brick works. The highest exposure to raw shale dust appears to have been at the face in mines (facemen and drawers) and the crushers at retort works. The highest exposure to spent shale was experienced by tipmen at retort works. Because the relative fibrogenicity of raw and spent shale in man is unknown, workers exposed to the two types of dust were separated in the classification. A large number of mineworkers were classed as 'elsewhere underground' since their dust exposure would have been greater than that of surface workers. A large

number of employees in the industry had remote or indirect exposure to shale dust and oil. These categories included canteen attendants, truck drivers, cooks, watchmen, office cleaners etc. The classification system allocated different codes to such workers, e.g., mines (Code 5) and retort works (Code 13). Similarly, maintenance workers were coded separately throughout the industry.

The hierarchy of jobs according to their relative dustiness throughout the industry that was used in the analysis is given in Table 3.1

TABLE 3.1

Hierarchy of job categories according to their relative dustiness (raw and spent shale combined).

1. No exposure (petroleum refineries etc.).
2. Shale oil refineries.
3. Mines : surface and opencast workings.
4. Retort works : elsewhere; brickworks.
5. Retort works : maintenance.
6. Retort works : retorting.
7. Mines : maintenance.
8. Mines : elsewhere underground.
9. Retort works : crusher.
10. Retort works : tipman.
11. Mines : faceworker

(c) Hierarchy of job categories according to exposure to oil and wax

It was recognised that the relative degree of exposure to oil in different jobs might have had a bearing on the incidence of skin cancer, although the composition of the oil is known to be more important.

The classification also permitted an analysis with a view to determining whether the kerogen present in raw shale caused skin cancer in exposed workers. Thus, miners and retort workers exposed to raw shale could also be entered into the analysis of the relationship (if any) of oil exposure to skin cancer. The heaviest exposure to cancer-producing substances was in the wax filtration plant, where workers cleaned canvas filters with their bare hands and forearms (until the process was mechanised in 1935). Exposure to purified waxes occurred, albeit less heavily, in the candle factory; therefore wax workers and candle manufacturers were grouped together. Relatively little direct skin contact with oil occurred in the refineries; therefore a highly-discriminant classification of job categories in the refineries was not attempted.

Manual coding of occupational histories

The list of codes that were used is attached, as Appendix 5. A formal study which was done to evaluate the dictionary and coding system suggested that the proposed method of job-coding was practical and free of systematic flaws. (Appendix 6).

The occupational histories were coded by the same clerk who took the narrative histories. A list of conventions was compiled to deal with situations requiring value-judgments. During the clerk's training period for this project, the records of some 1 200 men were re-coded (by SJL). Discrepancies between the two sets of codes were noted and the reasons for this occurrence discussed; corrections were then made by consensus. Subsequently, an extensive computer validation programme was performed to detect residual coding errors.

In order to make comparisons between the P-Form and clerk-obtained histories, a three-tier coding system was developed (Fig. 3.2). Thus, the job held during any given period of a man's life was coded according to the clerk's history and according to the P-Form history.

Table 3.2
Example of three-tier code

1st Tier (place of work)	2nd Tier (job title on P-Form) e.g., miner	3rd Tier (job title given to clerk) e.g.,haulageman	From 1.7.52	To 15.12.53
01	65	02	07:52	12:53

The adoption of this coding system shed light on some of the questions regarding "vague" terms and movements of workers within the industry. It also permitted the testing of the validity of assumptions regarding the men's activities during the periods that were not accounted for on the P-Forms.

3.4.2 Dermatology Questionnaires

(a) Rationale

To determine the prevalence of skin disorders among the largest possible number of ex-shale workers (and a control population), a simple, self-administrable questionnaire was designed which could be sent by post. After testing the questionnaire amongst employees in the IOM, it was used in the format illustrated in Appendix 7.8 and sent to all men who had agreed to participate in the survey (see Section

3.3). It was accompanied by a brief introductory letter and by a questionnaire on smoking habit (see below).

(b) Difficulties

A number of questionnaires were returned having been incompletely filled in, using ambiguous marks, or with contradicting answers. It was decided to enter all answers (whether correct or otherwise) on computer file after which invalid forms were identified, using the criteria described in Appendix 8. Upon careful consideration it was decided to edit those 'erroneous' questionnaires that could be edited without revision by the individual concerned, using a set of pre-determined conventions (see Appendix 8). Those that could not be edited were returned to the men for revision. Whenever possible the forms for revision were taken to the men's homes by IOM clerks. The revision forms were duplicates of the original questionnaires with asterisks marked against the questions which each individual had answered in an uninterpretable way. The clerks were instructed to obtain revisions of the marked questions only. Men who lived outwith West Lothian were contacted by telephone whenever possible. The remainder were contacted by letter, requesting revision of the relevant questions only.

3.4.3 Smoking Questionnaires

(a) Rationale

One purpose of this survey was to obtain information on the smoking habits of shale workers for the concurrent mortality study. Therefore it was necessary to study the largest possible population, which led to the decision to do a postal questionnaire survey. The other purpose was to obtain data that would be helpful in the interpretation of abnormalities of chest radiographs and pulmonary function tests in the present study.

The questionnaire (Appendix 7.9) was a modification of one which had previously been used by the IOM in a study of polyvinylchloride workers.[9] That questionnaire was, in turn, based on the tobacco-smoking section of the MRC questionnaire;[10] ours was more detailed and less prone to ambiguity if men had previously smoked more than one type of tobacco (e.g., cigarettes and pipe), but subsequently stopped smoking one type. It was, probably, also more readily understandable by the subjects. The section in the MRC questionnaire on "small cigars" was omitted for brevity. The questions on the inhalation of smoke and cigarette brand names were omitted because they were irrelevant to the present study.

(b) Difficulties

As was the case with the skin questionnaires, some answers contained apparently unintentional omissions and a number contained contradictory answers (especially involving the calculation of years spent smoking). Since conventions could not be made to

edit such errors or omissions, all these questionnaires were taken to the men for revision, using the same procedures as outlined in Section 3.4.2.

3.4.4 Chest Radiography Survey

The data for the radiography survey were gathered in two phases. The first was the field survey, where the X-ray plates were made in a standardized way; the second was the classification of the radiographs by a panel of readers.

X-ray Field Survey

Since the study involved the workers of a defunct industry, it resembled a community-based survey, involving, predominantly, elderly men who were living in a number of different towns in West Lothian. To improve the cost-effectiveness of the survey and bearing in mind factors such as the geographic distribution of the participants, bus routes and complexity of town lay-outs, the survey was done at suitable sites in each of three towns, namely, Winchburgh, Pumpherston and Grangemouth.

All men in West Lothian who had agreed to participate in the radiographic study were visited by the survey clerks, who gave them appointments. More than 90% required transport in the IOM's mini-bus. In order to accommodate men who had work commitments, two evening sessions were held every week. Men who failed to turn up were visited again and new appointments were given; some men required several reminders. By these means it was attempted to maximize the response rate.

Upon arrival at the survey van, each man was registered by a receptionist and interviewed by an industrial history clerk (see Section 3.4.1), after which a postero-anterior

X-ray film was taken. Using a Siemens Polyphos 300 X-ray generator, films were taken with a relatively high kilovoltage (110-120kV) technique and a moving grid. The films were developed immediately in a 3MXP510C automated processor. The developed films were checked for technical quality by the radiographer before the men left the survey vans; if necessary, a repeat film was made and both were submitted to the medical reader.

Individual films were read within 48 hours, in order to identify cases requiring clinical intervention (e.g., cardiac failure, carcinoma etc.). Letters were sent to all men, informing them of the results of their radiographs. Abnormal features were discussed with another chest physician and, if any abnormality requiring intervention or further investigation was found, a letter giving a description of the radiographic features was sent to the man's general practitioner; simultaneously, a letter was sent to the man, in which he was advised to visit his doctor. No attempt was made to classify the films for pneumoconiosis during these clinical readings. Subjects were informed that they had "dust" in their lungs only if radiographic appearances indicated a severity of pneumoconiosis which might result in a successful claim for compensation.

Classification of Radiographs

The radiographs were read and classified independently by ten readers, using the protocol described in "Guidelines for the use of ILO International Classification of Radiographs of Pneumoconiosis - Revised Edition 1980".[11]

The panel of readers consisted of 4 medically qualified and 6 self-trained para-medical staff readers. Three of the medical readers had had extensive experience in the epidemiological reading and classification of radiographs.

The fourth medical reader underwent a preliminary training period, involving the reading of films of coalworkers and asbestos workers. The training and testing procedures of the para-medical panel have been described in detail elsewhere.[12] These readers continue to undergo periodic tests to determine whether any drift in reading-habit has taken place, by repeatedly reading 200 'calibration' films at irregular intervals.

The total number of films arising from the present survey was 1 231. In order to obtain an additional measure of the inter-reader variability and the sensitivity of the panel as a whole, 140 additional 'calibration' films were randomly inserted among the shale films. These films consisted of a stratified random sample of films taken at previous surveys in the Pneumoconiosis Field Research (PFR) Studies by the IOM at ten selected collieries. Twenty films from each of seven categories (0/0, 0/1, 1/0, 1/1, 1/2, 2/1 and 2/2) were included. It was thought that the precaution of inserting these films might prove particularly relevant if none (or very few) of the shale films were found to have small opacities. Thus, in total, 1 371 films were read. The films were read in random order, having been split into seven batches of about 200 films each, one complete batch always being read in a single reading session. The same light box and reading room was used by all readers and the results of each film were recorded by an experienced clerk on pre-printed forms.

3.4.5 Lung Function Survey

This survey was carried out in order to determine what were the effects (if any) of pneumoconiosis on lung function.

(a) Selection of cases and controls

After exclusion of films belonging to men who had worked in the coal industry (181) and incompletely

reported films (7), 1 044 films were available for the selection of cases and controls. On reviewing the distribution of the classified films, it was decided to select cases from a group of 182 films with a small opacity profusion rating equal to or greater than 1/1 as agreed upon by at least five readers. Selection was deliberately biased to include 47 films on which at least five readers agreed on a profusion of 1/2 or more. Thus a primary list of 60 "cases" (films with small opacities), stratified to include approximately similar numbers in each age category was made up, along with a list of reserves . The occupational histories and results of the clinical readings of the "cases" were then studied and men were disqualified (and replaced by reserves) if any of the following criteria applied:

(i) never exposed to shale dust (i.e., lifelong refinery workers);
(ii) enlarged cardiac shadows;
(iii) marked unilateral diaphragmatic elevations;
(iv) extensive pleural thickening;
(v) pigeon fanciers' lung; and
(vi) cryptogenic fibrosing alveolitis.

Names on the reserve list were also used if men on the primary list refused to participate in the study, were too ill to participate or failed to provide satisfactory tracings for either the gas transfer test ($TLCO_{SB}$) or the flow-volume test at survey.

The control group was initially selected from films which had been classified either as 0/0, 0/1 or 1/0 by all readers; in order to obtain a sufficient number of films, this criterion was extended to include films which had been classified as 0/0 or 0/1 by nine readers or eight readers. Films were preferentially selected from the first list (10

readers agreed), followed by the second list (9 readers agreed), and, finally, the third list (8 readers agreed). The latter two lists were mainly required to increase the number of men in the older age groups. The selection of the control population was stratified to match the age-distribution of the case population. The same criteria as those for the case population were used to bring into action substitutions from the control reserve lists. Apart from the requirement that men should have worked at a site (mines, quarries, retort works and brickworks) where exposure to shale dust would have taken place, no more detailed account of occupational history was taken into consideration during the selection of the control population. The details of duration of work in given job categories (and hence a crude estimate of relative dust exposure), smoking history and height were, however taken into account in the interpretation of the results of the lung function studies (see Results Section 4.7).

(b) Field survey

Prior to the survey, letters were sent to men who had been selected inviting them to take part in the lung function survey. Thereafter the survey clerks visited them at home and, if they agreed, gave them appointments to be collected by the IOM mini-bus. Evening sessions were held twice a week, to accommodate men with work commitments. Upon arrival at the laboratory, men were registered by a receptionist who also measured their standing height and who administered the respiratory symptoms questionnaire (see 3.4.6).

The pulmonary function measurements were done in the IOM's mobile laboratory by three experienced technicians, who had been engaged in surveys of this nature for 27, 8 and 5 years respectively. For the duration of the survey each technician was

responsible for all tests carried out with one apparatus. Forty-eight hours were allowed for stabilisation of the apparatus prior to commencement of the survey. Regular calibration checks were done according to a schedule and whenever indicated. Heating of the laboratory was maintained as constant as possible. Barometric pressure readings were taken at least twice every day and temperature readings were taken during the testing of each individual man. Men were asked not to smoke for at least an hour before testing. Results were reviewed daily by a lung physiologist to assess their plausibility and in order to make appropriate substitutions.

(i) Ventilatory capacity and maximum expiratory flow were measured with an electronic dry rolling-seal spirometer (Morgan, M8; PK Morgan Ltd., Chatham, Kent). Three satisfactory forced expirations were recorded as flow-volume curves on a fast-response X-Y recorder (Hewlett-Packard, Model No. 7045A). The maximum values of the forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were used for analysis; these two values were not necessarily taken from the same curve. Maximum expiratory flow rates at 50% and 25% of the vital capacity ($Vmax_{50}$ and $Vmax_{25}$) were also read from the curve giving the highest values.

(ii) Single breath gas transfer factor (syn. diffusing capacity; $TLCO_{SB}$; DLCO) was measured by the breathholding technique of Meade *et al*[13]. Duplicate readings were made at least 10 minutes apart, using a "Transfer Test B" apparatus (PK Morgan Ltd., Chatham, Kent).

(iii) Lung volumes were measured by the multiple breath helium-dilution technique using a closed circuit spirometer system (PK Morgan Ltd., Chatham, Kent), to obtain the residual volume and total lung capacity.

3.4.6 Respiratory Symptoms Questionnaire

A simple questionnaire (see Appendix 7.12) based on that of the British Medical Research Council[10] was administered to all men attending the lung function survey by a clerk specially trained and experienced. It was used to identify men with and without symptoms of respiratory disease.

3.4.7 Control Populations

BP (Grangemouth) Refinery workers and Young's Paraffin Light and Oil Co. workers

It has already been mentioned that 533 Provident Fund members were (or had been) petroleum refinery workers, or workers in a detergent soap factory and had never been exposed to shale oils. These "non-exposed" Fund members formed a valuable comparison population, since the tracing, contact and survey procedures of them were identical to those adopted for the exposed group. They were used as a comparison population for the skin questionnaire survey and as an unexposed group for the radiological survey. The detergent soap factory was previously a shale oil refinery, and since there are still spent shale dumps nearby these workers were regarded as having had low-grade shale dust exposure. This group was, however, excluded from the lung function survey.

Lung function survey controls

The criteria for selection of this control population were discussed in Section 3.4.5.

Dermatology questionnaire control study of ex-colliers

(a) Selection of control population

In order to obtain a control population most comparable to the shale miners for the purposes of the skin questionnaire, a number of considerations were taken into account:

(i) Since sunlight exposure is a known cause of skin cancer, shale miners should be compared with other miners, who are likely to have had similar exposure to sunlight. Coalminers are particularly suitable, since the organisation of shift-hours in the UK was similar in the two industries.

(ii) The control population should have a similar age structure and, ideally,

(iii) their duration of employment should be comparable to the shale-miners.

(iv) The selected colliery should not have been greatly mechanised, since the dermatotoxicity and/or carginogenicity of the oils used in modern machines is unknown.

A colliery in North East England, which was closed in 1974, satisfied all these criteria. Workers at the colliery had been the subject of several radiological surveys by the IOM, the last of which was done in 1973. There was anecdotal evidence that no significant emigration out of County Durham had occurred.

Using the IOM's records of the last two radiological surveys of the colliery, a potential study population of 715 was identified, 131 of whom were later discovered to have died. Three senior retired mine officials were employed to do the tracing by local enquiry; the tracing procedure closely resembled that used in tracing the Provident Fund members (see section 3.2).

Men who failed to respond to the letters sent to the addresses obtained by local enquiry were also sent letters through the DHSS letter forwarding service to these men (section 3.2.3). Similarly, letters were sent to a sample of 15 men, randomly selected from the 96 whose addresses we could not obtain by local enquiry.

(b) Modification of skin questionnaire

As discussed in Section 3.4.2, a substantial proportion of questionnaires that were sent to shale workers were returned with uninterpretable answers or omissions requiring revision. It was therefore decided to modify the questionnaire before despatch to the coalminers (controls) in an attempt to reduce the frequency of such errors. It was recognised that the phrasing of the questions should not be altered, but minor improvements in lay-out and clarification of the instructions could make unintentional omissions more obvious to the respondents. After considering several alternatives, the design (Appendix 7.9) was adopted. On it Question 1 is a consolidation of Questions 1 and 2 of the original questionnaire, since these two questions were treated in combination at analysis (see Convention B1, Appendix IX). It will also be noted that the instruction after Question 2 ("If YES to either of the above questions, please answer the

following:") was omitted. It was evident that this instruction had led to confusion in some respondents, causing them to leave out sections of subsequent questions, in a haphazard manner. Thus, the control questionnaire invited respondents to answer all questions, regardless of their answer to Question 1.

A draft of the modified form was sent to 20 randomly selected members of the control population, with a note requesting their comments on the design. Since none recorded any adverse criticism, the questionnaire was sent to the remaining members of the control population without significant modification. As with the shale population, reminders were sent by recorded delivery to those men who failed to respond within 3 weeks.

3.4.8 Analytical Methods

These are described in each part of the results section.

3.5 Ethical Considerations, Authorisations and Publicity

The principal ethical consideration was the maintenance of confidentiality of all information pertaining to individual men. Since the IOM has dealt with such data for many years, no special arrangements were required. Permission to use the Provident Fund records was obtained from the Management of British Petroleum and the Medical Officer at the Refinery at Grangemouth. Local contact was maintained with the West Lothian District Health Council and ethical approval was obtained from the West Lothian Medical Committee. The relevant Union representatives at the BP Refinery agreed to encourage their members to participate.

To promote interest in the study Dr. A. Seaton gave interviews to newspapers and he also took part in an interview at the regional radio station. The District Health Council agreed to inform their officials of the study and to advertise the study in their community offices. In order to encourage men to return their invitation-reply slips and questionnaires, the existence of a raffle was announced in the invitation. No doubt the numerous personal interviews by IOM clerks in the region served to sustain interest in the study.

CHAPTER 4
RESULTS

4.1 General response

The methods for tracing survivors have been recorded in Section 3.2 and Figure 3.1. Overall, 6 359 P-forms were identified and of these 2 618 referred to men who had died before 1.1.83. A further 159 had emigrated and for 16 men vital status was undetermined. This left 3 566 men known to be alive in the UK on 31.12.82 who were eligible for study. Invitations to take part in the study were sent to all these men. 360 replied positively but failed subsequently to take part. 425 either refused or were too ill to participate while no response at all was received from 1 117 men. Thus 1 664 of 3 566 men (46.7%) actually took part. The radiological survey included all of these men living in West Lothian who agreed to have a radiograph of their chest, and an internal control group of non-dust-exposed men also were included in the study definition (all members of the Provident Fund). In all 1 231 took part in this survey. Moreover, a number of responses to the smoking and skin questionnaires were found to contain ambiguities or missing answers and so were excluded from analysis. The overall responses are illustrated in Figure 4.1.

4.2 Comparisons of responders and non-responders

Since it proved impossible to study the entire surviving population, it was necessary to make some comparisons of those who took part in the surveys with those who did not, in order to assess the amount of bias likely to have been introduced by, for example, a high proportion of the elderly or more highly dust-exposed men not taking part. Comparisons were therefore made between the 1 225 men who attended for chest radiography <u>and</u> completed both the questionnaires, the 439 men who only

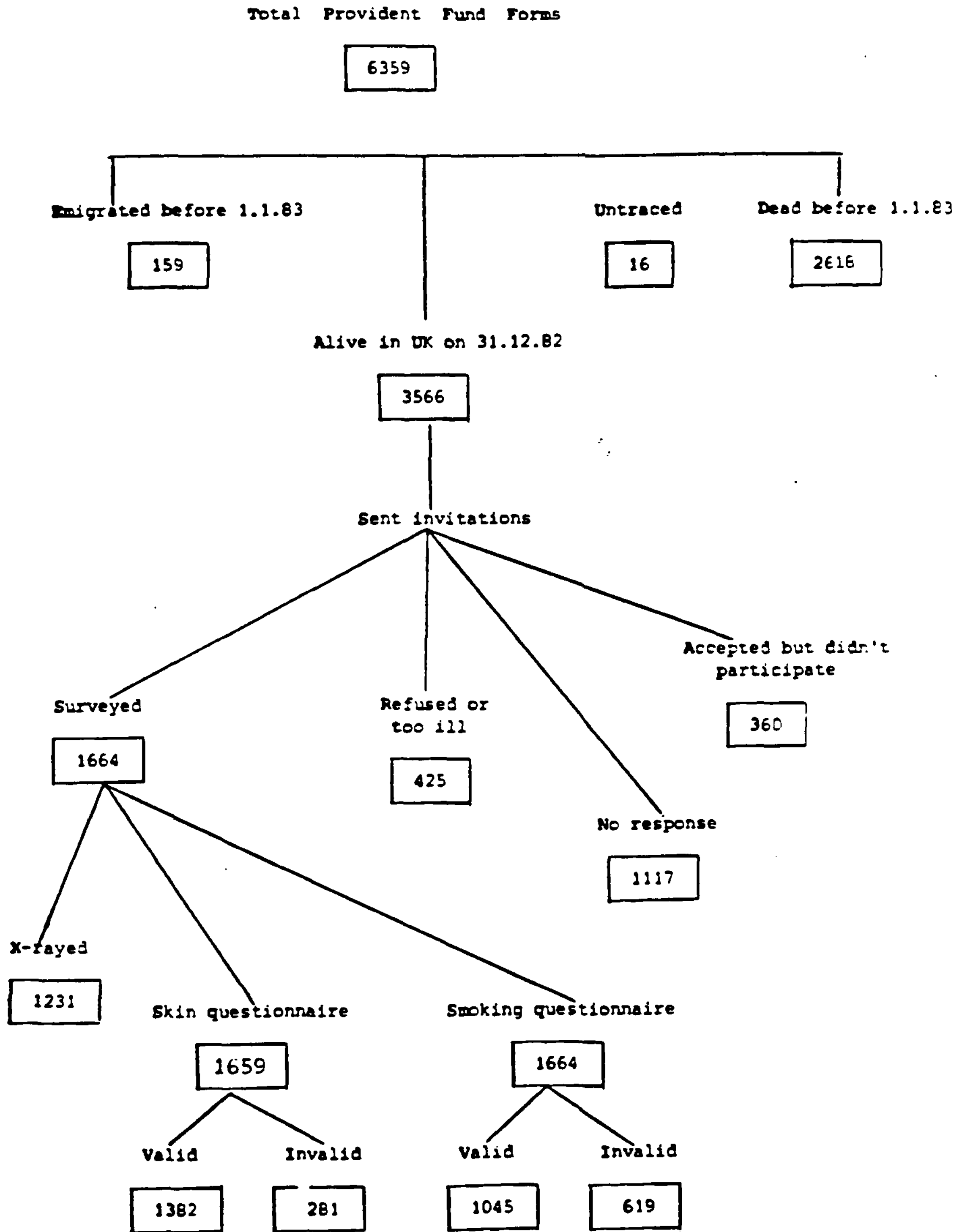


Figure 4.1: Distribution of the Provident Fund population between the various studies.

completed questionnaires and the remaining 1 885 men who did neither.

4.2.1 Age distribution

The age distributions of the three groups were very similar (Table 4.2.1).

Table 4.2.1

Ages of responders and non-responders

Group	Number of Men	Age Group ≤35	36-55	56-75	>75
X-ray & questionnaire	1 225	64 (5.2%)	559 (45.6)	522 (42.6)	80 (6.5)
Questionnaire only	439	23 (5.2)	209 (47.6)	172 (39.2)	35 (8.0)
Neither	1 885	103 (5.5)	904 (48.0)	739 (39.2)	139 (7.4)

4.2.2 Occupational histories

There were no very marked differences between the three groups with regard to types of workplaces and job codes mentioned in their occupational histories. However, Table 4.2.2 shows that the histories from the non-responders contained fewer references to shale mines and slightly more to the Middleton Hall administrative offices. More of their jobs were classified as "unknown in shale". The relatively more frequent references to jobs at Grangemouth in those who attended the radiological survey occurred because such workers were included deliberately to provide some radiographs from non-shale-exposed controls (Section 3.4.7).

Table 4.2.2

Distribution of workplaces

Workplace	X-ray + Q'aire	Q'aire	Neither
	Number (%) of jobs		
Shale miners	1772 (46)	384 (45)	1 374 (37)
Retort works	518 (13)	105 (12)	517 (14)
Refinery	405 (10)	100 (12)	449 (12)
Depots and jetties	12 (0)	8 (1)	59 (2)
Brick works	47 (1)	6 (1)	51 (2)
Middleton Hall	145 (4)	36 (4)	325 (9)
Grangemouth	934 (24)	144 (17)	586 (16)
Shale quarry	5 (0)	1 (0)	0 (0)
Unknown (in shale)	1 (0)	3 (0)	339 (9)
Unknown (outside shale)	4 (0)	62 (7)	40 (1)

NOTE: In this Table, numbers and percentages refer to the jobs and not to numbers of men.

Slightly more of the X-rayed men started work in the shale industry before 1940, while more of the questionnaire-only respondents were first employed between 1940 and 1960 (Table 4.2.3).

Table 4.2.3

Date of first job in shale industry

Year	X-ray + Q'aire	Q'aire	Neither
pre 1921	54 (4.4%)	21 (4.8)	72 (3.9)
1921 - 40	320 (26.1)	83 (18.9)	363 (19.7)
1941 - 60	613 (50.0)	264 (60.2)	1106 (59.7)
1961 - 80	238 (19.4)	71 (16.2)	311 (16.8)

No important additional differences were found when the three groups were analysed with respect to the workplace of their first job in the shale industry. However, separation of men into the dustiest workplaces in which they had been employed

for 3 or more years did show that in general heavily dust-exposed men were over-represented in the group who attended the X-ray survey while the non-responders included a large number of non-dust-exposed men (Table 4.2.4).

Table 4.2.4

Dustiest workplace for 3 years or more

Group	No exposure	Refinery	Retorts	Mine	<3 Years
			Workplace		
X-ray & Q'aire	501 (41%)	94 (8)	163 (13)	464 (38)	3 (0)
Q'aire alone	159 (36)	28 (6)	24 (6)	107 (24)	121 (28)
Neither	1221 (65)	104 (6)	128 (7)	390 (21)	42 (2)

Since this might in part be an effect of job histories being more accurate in men who attended for X-ray, the occupational histories were reanalysed excluding those jobs for which the P-form job code was missing but in which valid data on workplace were recorded. This resulted in some redistribution of men between exposure categories. Table 4.2.5 records these results which lessen the differences, but still indicate that the X-ray survey group, if anything, was biased towards the more heavily dust-exposed men.

Table 4.2.5

Dustiest workplace for 3 years or more (omitting unknown job codes)

Group	No exposure	Refinery	Retorts	Mine	<3 Years
		Workplace			
X-ray & Q'aire	585 (48%)	92 (8)	151 (12)	394 (32)	3 (0)
Q'aire alone	157 (36)	28 (6)	24 (6)	107 (25)	121 (28)
Neither	1224 (65)	105 (6)	125 (7)	382 (20)	45 (2)

4.3 Occupational histories

In total, the occupational histories of 1 779 men have been analysed in order to relate occupation to results from the dermatology, radiographic and lung function surveys. These histories came from the P-forms of the 1 664 men who took part in the surveys plus a further 115 of the 360 men who accepted but did not participate (see Fig. 4.1). These P-form histories contained all jobs held until the date of joining the Fund and, in addition, for those men who had left the employment of BP Oil at the time of the survey, a "last occupation" (see Section 3.4.1). Of the 1 231 men who attended for chest radiography, all save seven completed a clerk-administered occupational history in addition (see Section 3.4.1) and this has been used to supplement the P-form history. The derivation of these occupational histories is given in Table 4.3.1.

A total of 14 082 jobs was recorded for the 1 779 men, the maximum number of jobs per man being 21. 1 774 of these jobs are P-form "last occupations" for which no starting date or length of employment is available. In 1 830 jobs no workplace was given on the P-forms.

The shale industry was defined as workplaces 1-6, 12 and 14 in Table 4.3.1. Of the 1 779 men, 1 251 (70%) worked in the industry at some time. The starting dates of the first job in the industry are summarised in Fig. 4.2, showing that 40% of the 1 251 men joined the industry before or during 1940 and a further 32% joined between 1941 and 1950.

Since shale mining ceased in 1962, jobs held after June of that year should not have involved exposure to shale dust or oil, with the possible exception of brickworks. The 14 082 jobs can be divided into those before and after that date, and those bridging it (Table 4.3.2).

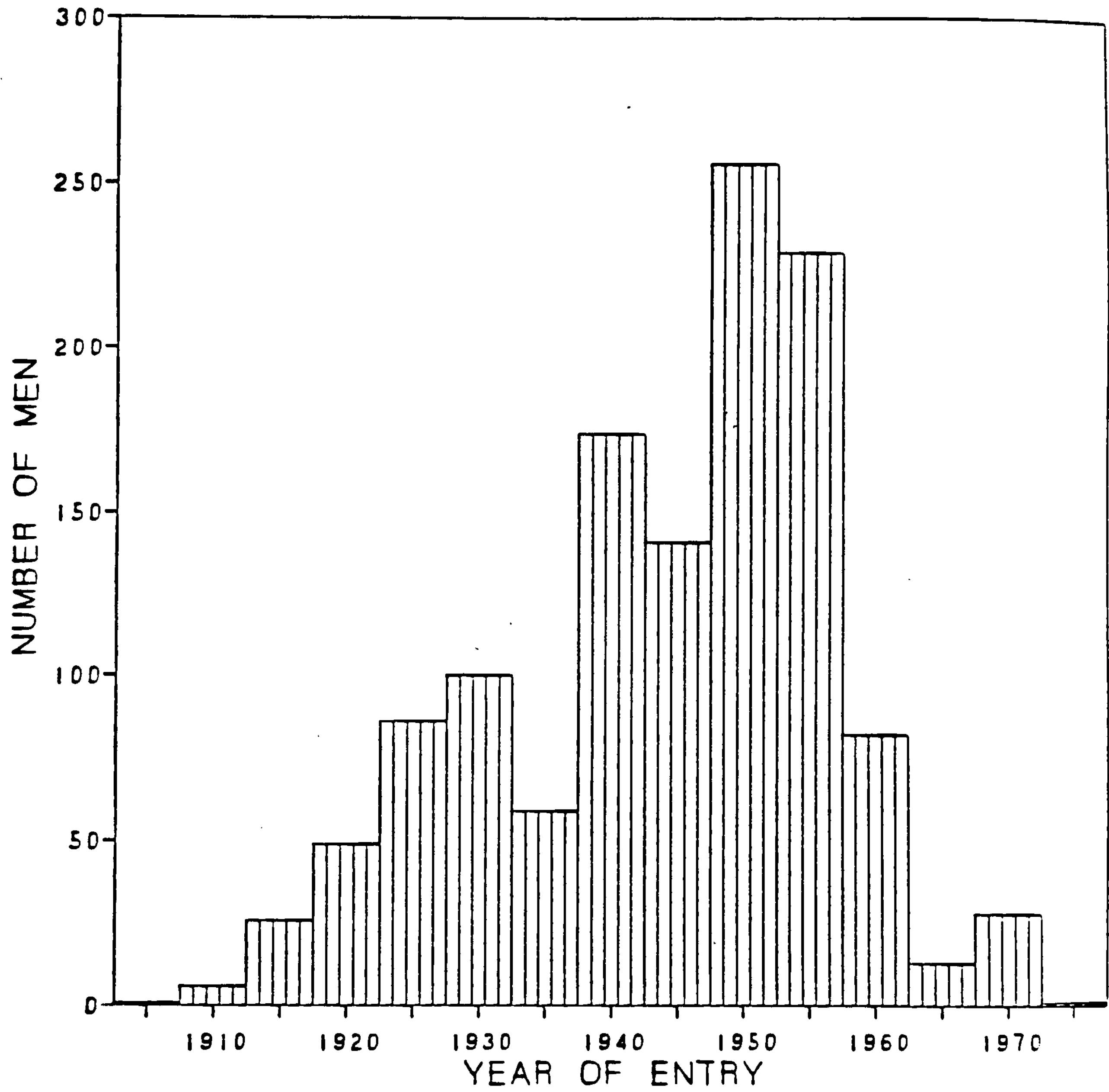


Figure 4.2: Distribution of date of starting first job in the shale industry.

Table 4.3.1

Distribution of jobs by workplace

Code	Workplace	Total	Number of Jobs			
			PF Only IV Missing	PF Missing IV Only	PF and IV	PF and IV Missing
1	Shale Mine	2238	454	392	1390	2
2	Retort Works	655	134	89	432	0
3	Refinery, Candle, Soap Works	549	140	112	295	2
4	Depot, Jetty Pipeline	26	9	0	12	5
5	Brickworks	56	8	14	33	1
6	Middleton Hall	271	41	0	149	81
7	Grangemouth	1109	164	430	512	3
8	Coalmining	359	10	2	347	0
9	Noxious Break*	583	1	581	0	1
10	Non-Noxious Break*	4635	135	0	4499	1
11	School	1234	0	0	1233	1
12	Shale Quarry	6	0	0	6	0
14	Unknown in Shale	395	0	0	0	395
15	Unknown outside Shale	136	94	0	5	37
	TOTAL	12252	1190	1620	8913	529

PF = Provident Fund History

IV = Clerk-administered History

For 1830 jobs no workplace was given. 1256 of these were Provident Fund "last occupations". For the remaining 574 both P-form code and interview code were missing.

*Noxious break indicates a job outside the shale industry in which there may have been exposure to harmful dust or fumes. Non-noxious break indicates a job with no such exposure.

Table 4.3.2

Jobs in relation to closure of shale industry

Job Description	Men X-rayed	Men Not X-rayed	Total
P-Form 'last occupation'	1225	549	1774
Jobs pre-June 1962	6578	1560	8138
Jobs bridging June 1962	1163	100	1263
Jobs post-June 1962	2776	131	2907

Of the 8 138 jobs pre-1962, 3 451 involved likely exposure to shale oil or dust (Table 4.3.3). Of the jobs bridging June 1962, only 133 involved probable exposure to shale oil or dust (Table 4.3.4). These were examined in detail to check that they were consistent with the closure of the industry at that time. All probably dust-exposed jobs (e.g. at mines and retorts) in this section finished within one year of June 1962 and it therefore seems likely that these men remained to oversee the closure of their workplaces. The largest group in this section consisted of 82 men at Pumpherston Refinery (job code 3). These works did not close down in June 1962, but converted to non-shale associated work. This has been allowed for in the allocation to 'oil-exposed' groups in the dermatology analyses (see Section 4.4). The jobs in which no workplace was recorded have not been used further in analyses, save those after June 1962, where no exposure to shale products has been assumed, as with all other jobs after this date except for 15 at brickworks (Table 4.3.5).

Table 4.3.3

Distribution of workplaces - jobs pre-June 1962

(a) Probable shale exposure

Workplace (see - Table 4.3.1)	Number of Jobs X-rayed	Not X-rayed	Total
1	1763	459	2222
2	517	134	651
3	262	125	387
4	0	4	4
5	30	5	35
6	109	37	146
12	5	1	6
14	0	0	0
TOTAL	2686	765	3451

(b) No shale exposure

Workplace	Number of Jobs X-rayed	Not X-rayed	Total
7	152	87	239
8	252	11	263
9	277	1	278
10	2039	110	2149
11	1166	4	1170
15	1	91	92
TOTAL	3887	304	4191

Note: 5 of the jobs of men X-rayed and 491 of those of men not X-rayed had no workplace recorded.

Table 4.3.4

Distribution of workplaces - jobs bridging June 1962

(a) Probable shale exposure

Workplace	Number of Jobs X-rayed	Not X-rayed	Total
1	16	0	16
2	4	0	4
3	79	3	82
4	3	1	4
5	5	1	6
6	20	1	21
12	0	0	0
14	0	0	0
TOTAL	127	6	133

(b) No shale exposure

Workplace	Number of Jobs X-rayed	Not X-rayed	Total
7	247	9	256
8	63	0	63
9	120	0	120
10	541	9	550
11	63	1	64
15	1	1	2
TOTAL	1035	20	1055

Note: 1 of the jobs of men X-rayed and 74 of those of men not X-rayed had no workplace recorded.

Table 4.3.5

Distribution of workplaces - jobs post-June 1962

Workplace	Number of Jobs X-rayed	Not X-rayed	Total
3	67	13	80
4	9	4	13
5	12	3	15
6	18	5	23
7	542	72	614
8	33	0	33
9	185	0	185
10	1908	28	1936
15	2	3	5
TOTAL	2776	128	2904

Note : 3 jobs of men not X-rayed had no workplace recorded.

4.4 Skin disease questionnaire

In total, 1 759 skin disease questionnaires were sent to men in the shale industry who had agreed to participate and 1 659 were returned. Of these, 281 contained errors that were not able to be corrected (see Section 3.4.2) and were excluded from analyses, leaving 1 378 on which the following results are based. Similarly, of the questionnaires submitted to the 503 coalminers identified as alive, 436 were returned and 49 of these were excluded because of errors. The results are recorded in Table 4.4.1. Men were separated into three groups, those exposed to shale dust and/or oil, other Provident Fund men and coalminers. No major differences in the prevalence of any skin condition were found between the oil/dust exposed men and those not so exposed. There was a much higher prevalence overall of skin disease in coalminers than in shale workers, this excess being concentrated among

Table 4.4.1

Positive replies to questions in skin disease questionnaire

	Exposure Group		
	Dust/Oil Exposed Shale[1]	Other Shale	Coalminers
No. of valid replies	929 (100)	449 (100)	387 (100)
Any skin trouble?	324 (35)	173 (39)	219 (57)
Eczema	40 (4)	24 (5)	16 (4)
Dermatitis	107 (12)	44 (10)	47 (12)
Psoriasis	43 (5)	13 (3)	18 (5)
Warts or moles	119 (13)	73 (16)	91 (24)
Skin tumours	8 (1)	1 (0)	5 (1)
Face ulcers	18 (2)	4 (1)	16 (4)
Arm or hand ulcers	13 (1)	3 (1)	11 (3)
Other ulcers	24 (3)	8 (2)	19 (5)
Itchy feet	75 (8)	29 (6)	92 (24)
Other skin condition	88 (9)	51 (11)	68 (18)
Operation for lump, mole	60 (6)	26 (6)	41 (11)
X-ray or radium treatment	13 (1)	2 (0)	10 (3)
Definite tumour[2]	20 (2)	3 (1)	13 (3)
Probable tumour[3]	51 (5)	25 (6)	34 (9)
Possible tumour[4]	114 (12)	64 (14)	84 (22)

Figures in parentheses refer to percentage of total replies.

1. Dust/oil exposed men had all at some time worked in a shale mine, quarry, retort or brickworks, or a refinery before 1962.
2. Definite tumours had replied yes to 'skin tumours or cancer' or 'X-ray/radium treatment'.
3. Probable tumours had replied yes to 'operation for lump, mole or or ulcer' but did not fall into 2 above.
4. Possible tumours did not fall into 2 or 3 above but replied yes to 'warts or moles' or ulcers on face/hand/arms or elsewhere.

those who recorded "warts or moles", "itching feet" and "other conditions or itch".

When men were grouped according to estimates of the severity of their exposure to shale dust or oil (Table 4.4.2), there was no indication of an excess of any skin condition amongst those with the highest exposures. A relatively low prevalence of psoriasis was noted among men with severe oil exposure.

The detailed occupational histories of all men reporting having had skin tumours or possible skin tumours were scrutinised. They had worked in the whole range of jobs and there was no clear evidence of any pattern of work or workplace associated with this diagnosis.

Formal chi-squared tests were carried out on a number of differences and showed that in a few instances (skin tumours and itchy feet) the excess in coalminers was unlikely to have occurred by chance. However, the large numbers of comparisons and the fact that these tests were carried out a posteriori mean that caution should be used in interpreting these findings.

Thus no excess of skin disease, as reported by questionnaire, has been found in this group of ex-shale workers compared to ex-coal miners, nor has any evidence been found of excess skin disease amongst men more heavily exposed to shale dust or oil compared to men not so exposed.

Table 4.4.2

Positive responses to skin disease questionnaire

	Exposure Group				
	Any Dust[2]	Severe Dust[3]	Any Oil[4]	Severe Oil[5]	Both[6]
No. of Valid Replies	778 (100)	461 (100)	508 (100)	143 (100)	357 (100)
Any skin disease	281 (36)	175 (38)	167 (33)	50 (35)	124 (35)
Eczema	34 (4)	19 (4)	22 (4)	7 (5)	16 (4)
Dermatitis	91 (12)	58 (13)	53 (10)	18 (13)	37 (10)
Psoriasis	39 (5)	23 (5)	21 (4)	2 (1)	17 (5)
Warts/Moles	101 (13)	60 (13)	65 (13)	18 (13)	47 (13)
Skin tumours	6 (1)	3 (1)	5 (1)	2 (1)	3 (1)
Face ulcers	18 (2)	10 (2)	10 (2)	2 (1)	10 (3)
Arm/hand ulcers	13 (2)	9 (2)	6 (1)	2 (1)	6 (2)
Other ulcers	21 (3)	11 (2)	13 (3)	1 (1)	10 (3)
Itchy feet	66 (8)	41 (9)	39 (8)	11 (8)	30 (8)
Other skin disease	75 (10)	47 (10)	44 (9)	13 (9)	31 (9)
Operation for lump/ mole	49 (6)	33 (7)	32 (6)	11 (8)	21 (6)
X/ray or radium	10 (1)	8 (2)	7 (1)	4 (3)	4 (1)
Definite tumour[1]	15 (2)	10 (2)	11 (2)	5 (3)	6 (2)
Probable tumour[1]	43 (6)	31 (7)	25 (5)	8 (6)	17 (5)
Possible tumour[1]	99 (13)	56 (12)	64 (13)	16 (11)	49 (14)

Figures in parentheses refer to percentage of total replies in each exposure group.

1 for definitions, see Table 4.4.1

2 worked in shale mine, quarry, retort or brickworks

3 worked in shale mine or quarry

4 worked in retort or refinery pre-1962

5 worked in refinery pre-1962

6 worked in a combination of 'any dust' and 'any oil' jobs.

4.5 Smoking questionnaire

4.5.1 General response

Smoking questionnaires were returned by 1 664 Provident Fund men. Many of these contained inconsistencies but the following rules were applied to determine whether men were current, ex- or non-smokers (see Questionnaire, Appendix 7):

Current smokers :	Q1 Yes and Q2 Yes or missing
Non-smokers :	Q1 and Q2 No
Ex-smokers :	Q1 No and Q2 Yes
	All of QQ 4, 13, 17, 21 No or missing
	Q25 answered or at least one of QQ 5, 14, 18, 22 Yes

This produced 773 current, 375 non- and 398 ex-smokers, with a residue of 118 unknowns. Of these unknowns, 76 were able to be classified by applying one of four rules:

current, except for Q1 Yes and Q2 No : Q2 ignored

current, since age when started and time smoked = age now

ex, since age when gave up + gaps in smoking history = age now

ex, since age when started + time smoked = age when gave up

This gave a final total of 826 current, 421 ex-, 375 non-smokers and 42 of unknown status. This information was used in analysis of the lung function results (Section 4.7).

4.5.2 Comparison of Provident Fund men and coalminers

The results from the smoking questionnaire have been compared with results obtained from a survey of the smoking habits of

972 Scottish coalminers and ex-miners, carried out by the IOM between 1978 and 1980.

The two groups were compared in terms of their age distribution at the time of survey. They were very similar in this respect (Table 4.5.1).

Table 4.5.1

Age distribution of respondents to smoking questionnaire

Age	Provident Fund Men	Coalminers
21-30	6 (1%)	0 (0)
31-40	110 (11)	80 (8)
41-50	250 (24)	178 (18)
51-60	298 (29)	305 (31)
61-70	215 (21)	279 (29)
71-80	129 (12)	120 (12)
81-90	35 (3)	10 (1)
91-100	2 (0)	0 (0)
TOTAL	1045 (100)	972 (100)

It should be noted that this table includes only 1 045 Provident Fund men. This is because only this number of forms contained sufficient unequivocal information for further analyses beyond simple separation into non-, ex- and current smoker as above.

Thus the shale workers that we surveyed had a very similar age distribution to that of the Scottish coalminers with whom we compared them. It is likely that their social class was also very similar, in that most members of both groups were predominantly skilled, semi-skilled or unskilled manual workers.

The following tables (4.5.2 to 4.5.4) compare smoking habits in the two groups. There were more life-long non-smokers amongst the shale workers and correspondingly fewer current smokers. The smoking shale workers included slightly fewer very heavy smokers of cigarettes and rather more heavy smokers of rolled or pipe tobacco.

Table 4.5.2

Smoking status

	Provident Fund Men	Coalminers
Current	438 (42%)	611 (63)
Ex	226 (22)	202 (21)
Non	374 (36)	142 (15)
Unknown	7 (1)	17 (2)
TOTAL	1 045 (100)	972 (100)

Table 4.5.3

Usual daily cigarette consumption (current smokers)

	Provident Fund Men	Coalminers
<1	30 (7%)	83 (14)
1-5	16 (4)	30 (5)
6-10	57 (13)	76 (12)
11-20	237 (54)	238 (39)
21-30	74 (17)	144 (24)
31-40	18 (4)	27 (4)
41-50	4 (1)	11 (2)
>50	2 (1)	2 (0)

Table 4.5.4

Total weekly consumption (rolled + pipe, ozs.)

	Provident Fund Men	Coalminers
<1	220 (50%)	486 (80)
1	32 (7)	55 (9)
2	69 (16)	52 (9)
3	39 (9)	14 (2)
4	49 (11)	3 (1)
5	12 (3)	1 (0)
>5	17 (4)	0 (0)

The following tables (4.5.5 - 4.5.7) give some further information on the smoking habits of Provident Fund men. In these cases insufficient information was available on records from Scottish coalminers for us to make any comparisons.

Table 4.5.5

Maximum daily cigarette consumption

	Current	Ex
<1	30 (7%)	6 (3)
1-5	6 (1)	7 (3)
6-10	39 (9)	39 (17)
11-20	206 (47)	91 (40)
21-30	94 (22)	33 (15)
31-40	47 (11)	30 (13)
41-50	6 (1)	7 (3)
>50	10 (2)	13 (6)

Table 4.5.6

Weekly cigar consumption

	Current	Ex
<1	341 (78%)	197 (87)
1-10	53 (12)	22 (10)
11-20	21 (5)	2 (1)
21-30	7 (2)	2 (1)
31-40	10 (2)	2 (1)
41-50	4 (1)	1 (0)
51-60	1 (0)	0 (0)
61-70	0 (0)	0 (0)
71-80	1 (0)	0 (0)

Table 4.5.7

Time spent smoking (years, current and ex-smokers)

1-5	10 (2%)
6-10	22 (3)
11-20	77 (12)
21-30	150 (23)
31-40	174 (26)
41-50	136 (21)
51-60	65 (10)
61-70	28 (4)
71-80	2 (0)

4.6 Chest Radiology

4.6.1 Description of data

One thousand two hundred and thirty-one men attended for X-ray during the radiological survey. The films, one for each of these men, were read by a panel of ten, four medical and six non-medical readers, resulting in a set of 12 310 readings. Of these, six films were classified as of unreadable quality by one reader, and one film was classified as unreadable by two readers, resulting in 12 302 valid readings. The eight invalid readings were omitted in the analyses. In the results that follow the medical readers are coded as nos. 010 to 014 and the non-medical readers as 101 to 112.

4.6.2 Reader agreement

The extent of reader agreement was assessed by calculating a consistency coefficient for each pair of readers. This coefficient represents the percentage of films for which the two readers agreed exactly on category of pneumoconiosis as defined by the 12-point scale.[11] The consistency coefficients are shown in Table 4.6.1(a). Table 4.6.1(b) shows the percentage of films for which each pair of readers agreed on category according to the 4-point scale. Although a fairly high degree of agreement can be seen between some pairs of readers, particularly among the medical panel, this is due in large part to the substantial number of films read as 0/0 by both readers. Two of the non-medical panel had substantially lower mean consistencies than the rest of the readers.

For an additional assessment of the reader consistency a set of 140 coalminers' films was included among the shale films (described in Section 3.4.4). Similar consistency coefficients for this set of films are shown in Tables 4.6.2(a) and 4.6.2(b). The lower percentages in these tables result from the uniform distribution of the coal films among the grades of pneumoconiosis giving a much larger percentage in the higher grades.

Table 4.6.1(a)

Consistency coefficients for exact matching

1231 shale films

	010	011	013	014	101	104	105	106	111	112	Mean consistency
010	100.0										47.9
011	75.7	100.0									53.7
013	55.3	58.4	100.0								46.1
014	71.0	68.2	59.1	100.0							52.2
101	21.1	27.9	25.9	26.7	100.0						26.8
104	45.6	49.9	48.8	48.9	31.8	100.0					43.0
105	40.0	44.8	39.6	44.3	32.9	47.2	100.0				39.4
106	90.2	74.5	54.6	70.3	21.0	46.0	40.9	100.0			53.3
111	15.3	18.4	15.4	17.1	28.6	19.8	22.3	15.9	100.0		18.7
112	66.6	65.3	57.4	63.9	25.3	49.4	42.8	66.3	15.1	100.0	50.2

Table 4.6.1(b)

Consistency coefficients for matching within one category

1231 shale films

	010	011	013	014	101	104	105	106	111	112	Mean consistency
010	100.0										66.2
011	84.9	100.0									68.2
013	80.2	82.4	100.0								67.4
014	84.6	82.8	82.9	100.0							66.0
101	47.9	53.6	52.9	52.3	100.0						52.1
104	60.9	68.2	71.3	70.5	61.5	100.0					62.3
105	44.5	53.8	55.1	53.3	65.2	69.0	100.0				53.3
106	93.1	84.8	79.5	83.7	48.7	62.7	46.7	100.0			66.6
111	15.5	19.2	21.0	19.1	34.2	27.2	36.9	16.7	100.0		34.3
112	84.3	84.2	81.6	83.1	53.1	69.6	55.0	83.9	18.7	100.0	68.2

Table 4.6.2(a)

Consistency coefficients for exact matching

140 coalminers' films

	010	011	013	014	101	104	105	106	111	112	Mean consistency
010	100.0										24.8
011	28.6	100.0									32.5
013	22.9	34.3	100.0								27.4
014	30.0	32.9	30.7	100.0							28.1
101	27.1	40.7	23.6	37.1	100.0						30.1
104	27.1	37.9	29.3	32.9	40.0	100.0					32.6
105	22.1	38.6	37.9	29.3	40.7	44.3	100.0				32.1
106	32.9	25.7	24.3	22.9	21.4	27.9	22.1	100.0			24.9
111	11.4	32.1	15.0	14.3	21.4	27.9	25.7	22.9	100.0		20.5
112	21.4	21.4	28.6	22.9	18.6	25.7	27.9	24.3	13.6	100.0	22.7

Table 4.6.2(b)

Consistency coefficients for matching within one category

140 coalminers' films

	010	011	013	014	101	104	105	106	111	112	Mean consistency
010	100.0										39.3
011	41.4	100.0									50.6
013	45.7	65.7	100.0								53.8
014	52.1	53.6	62.1	100.0							49.0
101	40.0	52.9	57.1	61.4	100.0						49.7
104	40.7	54.3	61.4	54.3	58.6	100.0					51.3
105	30.0	57.1	61.4	50.0	63.6	60.0	100.0				51.1
106	47.1	41.4	41.4	37.1	38.6	42.9	34.3	100.0			40.4
111	16.4	37.1	28.6	17.1	23.6	33.6	42.1	31.4	100.0		29.5
112	40.7	52.1	62.1	53.6	51.4	55.7	61.4	49.3	35.7	100.0	51.3

Since, as is usual in such surveys, these differences occurred between readers the relationship between dust exposure and degree of pneumoconiosis has been analysed for each reader separately. The distributions of categories recorded by each reader are shown in Table 4.6.3.

Table 4.6.3

Numbers of films (percentages) in each pneumoconiosis category, as recorded by each reader

Cat. of pneumoconiosis	Reader No.									
	010	011	013	014	101	104	105	106	111	112
3/3+	3 (0.2)	9 (0.7)	4 (0.3)	1 (0.1)	1 (0.1)	6 (0.5)	3 (0.2)	8 (0.7)	130 (10.6)	2 (0.2)
3/2	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1 (0.1)	4 (0.3)	0 (-)	1 (0.1)
2/3	0 (-)	0 (-)	3 (0.2)	1 (0.1)	0 (-)	1 (0.1)	1 (0.1)	4 (0.3)	3 (0.2)	9 (0.7)
2/2	4 (0.3)	25 (2.0)	9 (0.7)	17 (1.4)	100 (8.1)	28 (2.3)	63 (5.1)	11 (0.9)	334 (27.1)	15 (1.2)
2/1	1 (0.1)	8 (0.7)	9 (0.7)	3 (0.2)	0 (-)	0 (-)	24 (1.9)	5 (0.4)	26 (2.1)	20 (1.6)
1/2	3 (0.2)	8 (0.7)	19 (1.5)	6 (0.5)	95 (7.7)	75 (6.1)	42 (3.4)	22 (1.8)	25 (2.0)	62 (5.0)
1/1	11 (0.9)	139 (11.3)	70 (5.7)	130 (10.6)	464 (37.7)	211 (17.2)	281 (22.8)	18 (1.5)	530 (43.1)	57 (4.6)
1/0	9 (0.7)	13 (1.1)	146 (11.9)	47 (3.8)	0 (-)	179 (14.6)	281 (22.8)	8 (0.7)	0 (-)	46 (3.7)
0/1	41 (3.3)	115 (9.3)	301 (24.5)	153 (12.4)	325 (26.4)	178 (14.5)	48 (3.9)	8 (0.7)	0 (-)	210 (17.1)
0/0	1154 (94.1)	913 (74.2)	670 (54.4)	873 (70.9)	246 (20.0)	552 (44.9)	487 (39.6)	1142 (92.8)	183 (14.9)	809 (65.7)

4.6.3 Analysis

The investigation of the risk of pneumoconiosis in relation to occupation was done, using a discrete "dust hierarchy" of workplaces, a crude dust exposure index, and formal statistical modelling techniques.

(a) Dust hierarchy analysis

For the analysis of the relationship between occupation and presence of pneumoconiosis, each man in the X-ray survey was assigned to one of four mutually exclusive workplace groups. These are, in order of increasing dustiness:

(i) no shale exposure;
(ii) refinery;
(iii) retorts and brickworks;
(iv) shale mines and quarries.

The men were classified according to the dustiest workplace they had ever worked in for three years or more, excluding men who had joined the Provident Fund after June 1962. It was thought that the three-year limit for allocation to a particular workplace gave a more accurate representation of a man's occupational exposure, while the exclusion of the men joining the Fund after the closure of the shale industry in 1962 in effect excluded younger unexposed men. This resulted in a more even age distribution among the dust categories (Table 4.6.4). The analyses were repeated excluding specific subgroups of the population, i.e. men ever exposed to coal dust or asbestos and men with "other radiological abnormalities" (e.g. pleural thickening, TB scars). No major differences resulted from any of these subsequent analyses and the results quoted below refer to all men joining the Fund before June 1962, allocated to the dustiest workplace at which they had worked for three years or more. Details of the population are shown in Table 4.6.5

Table 4.6.4

Age distributions of study population and subgroups

		No Exposure	Refinery	Retorts	Mines
ALL MEN	Mean	50.78	58.90	61.50	61.64
	s.d.	11.5	12.5	11.2	11.6
	(No. of men)	(505)	(96)	(164)	(465)
PRE 1962 MEN	Mean	56.84	59.91	61.59	61.64
	s.d.	9.9	11.9	11.2	11.6
	(No. of men)	(279)	(89)	(163)	(465)
PURE SHALE MEN	Mean	56.43	61.88	62.20	61.87
	s.d.	9.9	11.8	11.5	11.8
	(No. of men)	(197)	(65)	(132)	(323)

"Pure Shale Men" excludes post 1962 men, coalminers, asbestos exposed men and men with other radiological abnormalities not attributable to dust.

Table 4.6.5

Description of the study population

Total number of men:	1231	
Number of men joining PF after 1962	235	
Number of men in workplace allocation	996	
(i) No exposure		279
(ii) Refinery		89
(iii) Retort/Brickworks		163
(iv) Shale Mines/Quarries		465
		996

All small opacities

Table 4.6.6 details the percentages of men classified 0/1+, 1/0+ and 2/1+ by each reader for the four dust groups. The information for percentages with 1/0+ and 2/1+ is also represented graphically in Figures 4.3 and 4.4. In Figure 4.4 the results for Reader 111 have been omitted since the inclusion of percentages of such large magnitude compared to the other readers would have caused the scale at the lower end of the graph to be compressed to such an extent that it would be impossible to differentiate between the results for the rest of the panel.

Table 4.6.6

Percentages of men classified as 0/1+, 1/0+ and 2/1+ by reader by workplace

	0/1+				1/0+				2/1+			
Reader	No exp.	Ref.	Ret.	Mine	No exp.	Ref.	Ret.	Mine	No exp.	Ref.	Ret.	Mine
010	4.7	5.6	6.1	8.9	0.8	1.1	1.8	5.4	0.0	0.0	0.6	1.6
011	25.4	28.4	31.9	29.0	15.0	13.6	21.5	20.8	2.2	2.2	3.6	5.8
013	41.2	44.9	54.6	54.2	16.8	21.3	28.2	26.9	1.1	0.0	1.8	4.1
014	26.9	30.3	40.5	33.5	14.0	15.7	23.3	21.5	0.7	0.0	0.6	4.0
101	81.4	89.9	87.1	84.5	52.7	74.2	56.4	59.6	4.7	16.9	9.2	11.4
104	52.3	65.2	66.7	62.6	36.9	50.6	53.1	46.7	1.1	3.4	3.7	5.0
105	59.9	75.3	62.6	67.7	58.1	71.9	59.5	62.5	5.7	11.2	7.9	10.9
106	6.8	9.0	8.0	9.3	5.7	9.0	7.4	8.4	2.2	0.0	3.0	4.0
111	85.3	93.3	89.0	89.0	85.3	93.3	89.0	89.0	36.6	60.7	47.2	46.1
112	32.3	38.2	44.8	40.9	15.8	22.5	19.0	23.1	2.2	2.2	4.9	6.4

In interpreting these results it is best to consider the medical and the non-medical readers separately. For the medical panel, as can be seen in Table 4.6.3, two read approximately similar percentages overall in each category while one read substantially lower (classifying only 3% of the films at 1/0 or greater). These differences are reflected in the actual percentages in specific workplaces shown in Table

4.6.6. However it can be seen that in general for each reader an increasing trend is seen towards the dustiest workplace (mines) for each of the chosen cut-off points (0/1, 1/0 and 2/1). The trend becomes clearer in the higher categories: for percentages with 1/0+ the retort and mine workers have similar magnitude but for 2/1+ the mine workers are clearly higher than all the others, between 1.6 and 5.8% of men being considered to have these changes. It should be noted that the latter figures are based on small numbers of men.

For the non-medical readers the patterns are not as clear. Again the marginal distributions for the readers are reflected in the magnitude of the percentages, though with one reader tending to read higher and one substantially lower than the others. At 0/1+ there is little difference among the four groups while for 1/0+ the only outstanding feature is an excess of men among the refinery workers as read by two readers. For films classified as 2/1+, in general there was an upward trend towards the shale mines but again the excess in refinery workers was recorded. These films were re-read from a clinical viewpoint and the occupational histories of the men studied to investigate any pattern amongst them, but nothing was found except many of the high category films read by these two non-medical readers were of poor technical quality.

Types of opacity

A further analysis of these data was done for the small opacities divided into predominantly rounded and predominantly irregular types. Table 4.6.7 shows that some of the non-medical panel had a tendency to classify as one or other of these types. However for the medical readers there is a fairly even distribution. Tables 4.6.8(a) and 4.6.8(b) show the percentages of men classified 1/0+ and 2/1+ by each reader, divided into these types. Figures 4.5 and 4.6 show the results for 1/0+ graphically. When the opacities are divided by type, the trend noted previously is not as strong as for both types combined. There is some trend apparent with irregular opacities for the medical readers for the percentage of men classified as 1/0+.

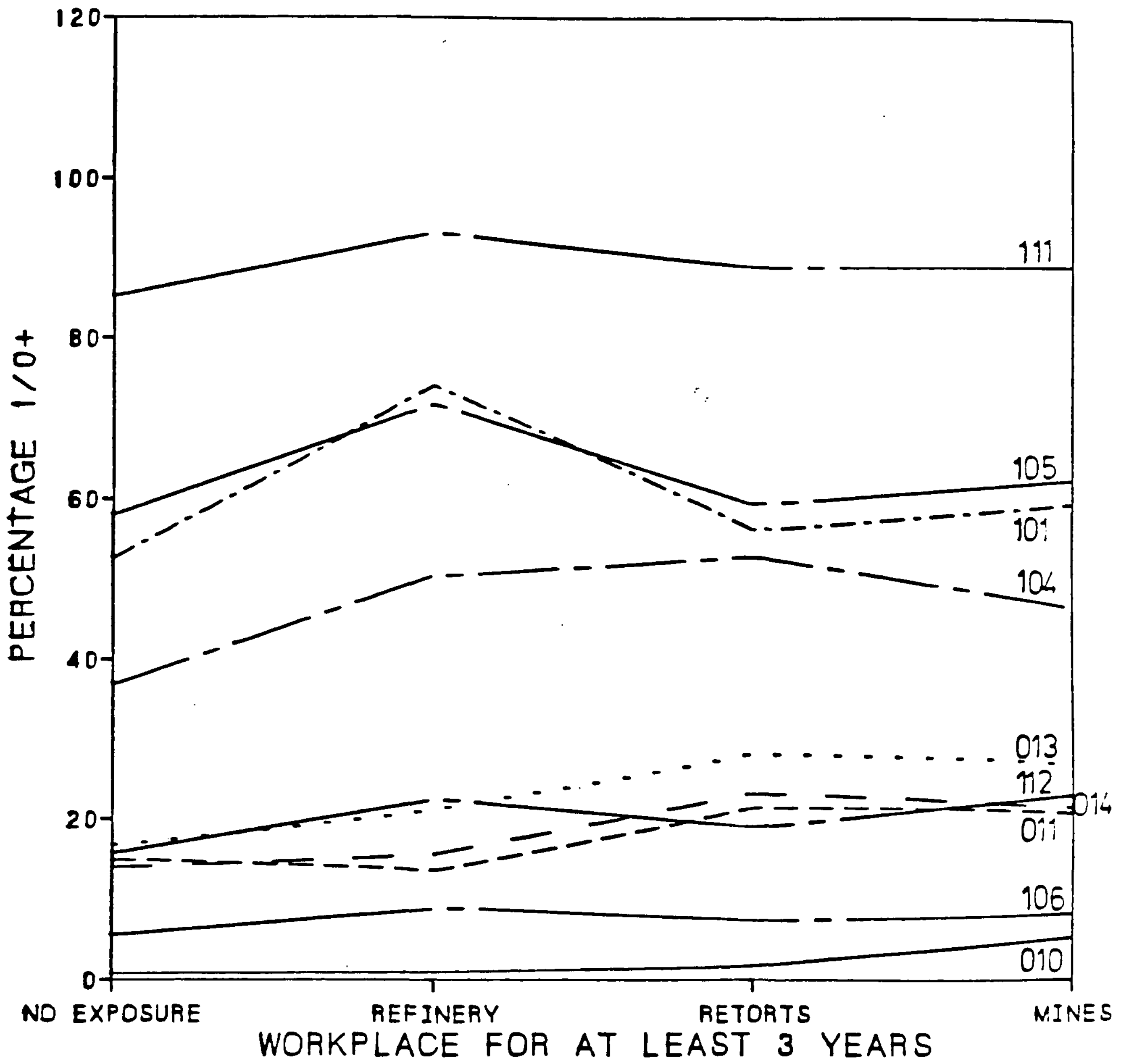


Figure 4.3: Percentage of men classified as 1/0+ by reader by workplace .

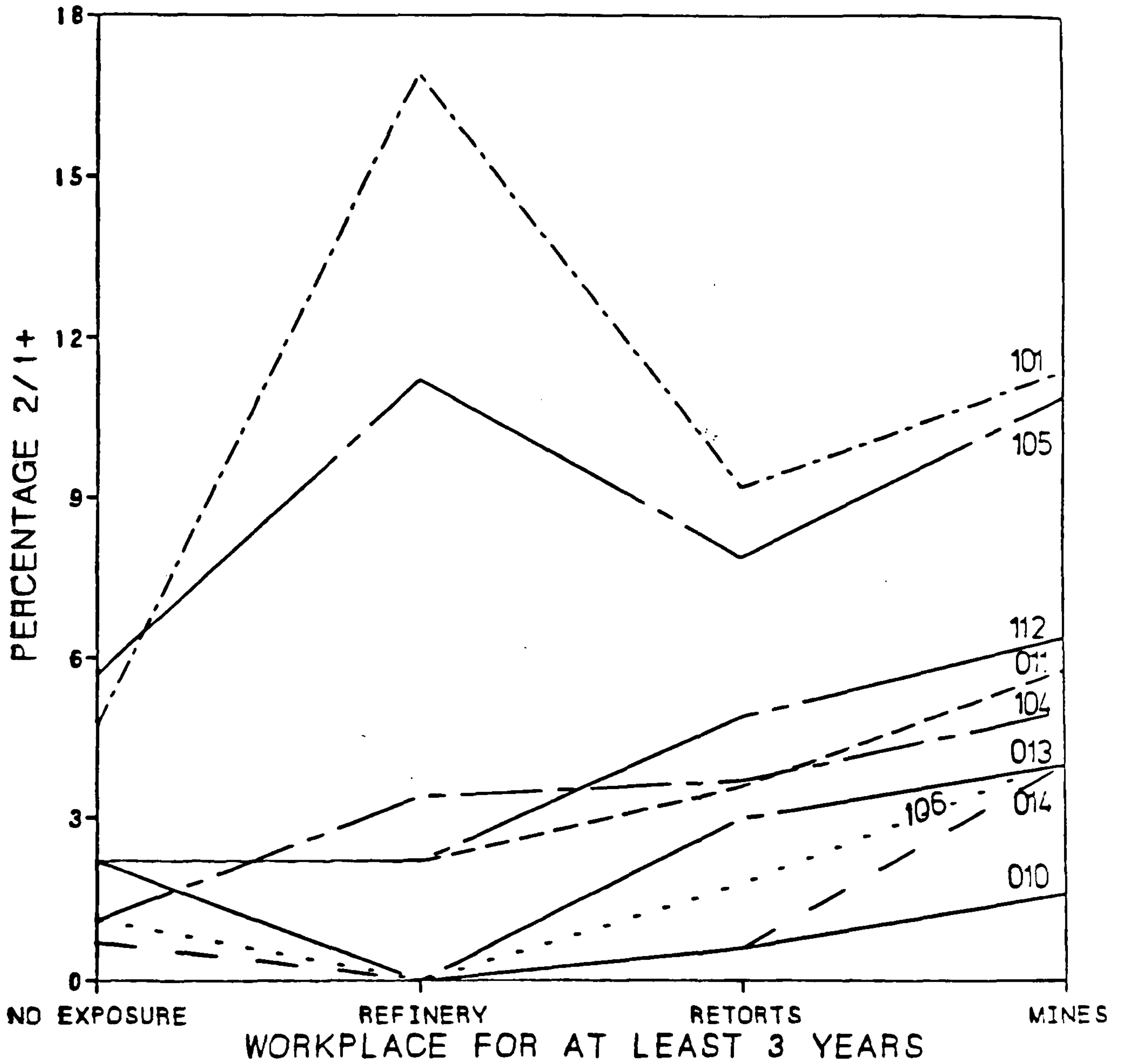


Figure 4.4: Percentage of men classified as 2/1+ by reader by workplace.

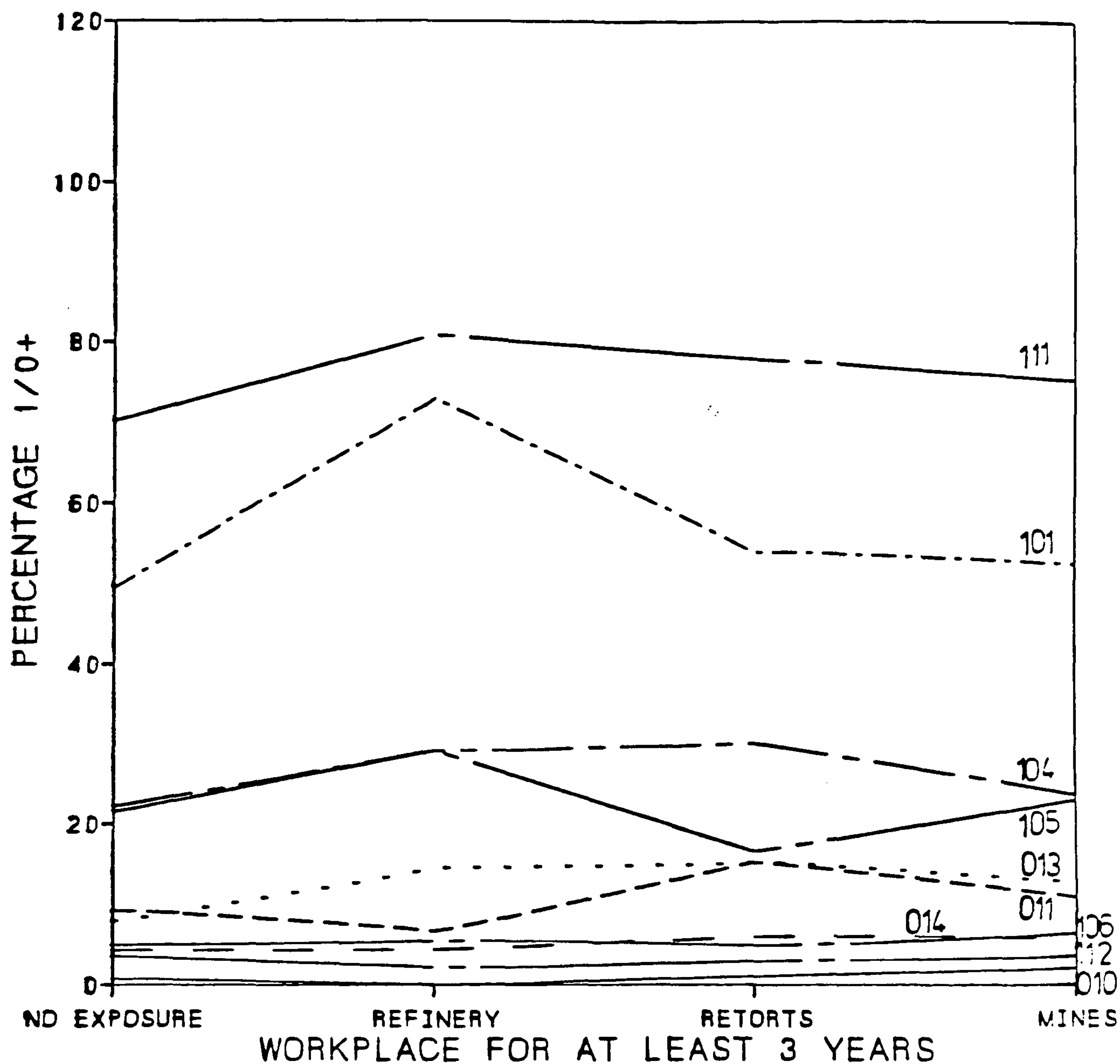


Figure 4.5: Percentage of men classified as 1/0+ by reader by workplace for rounded opacities.

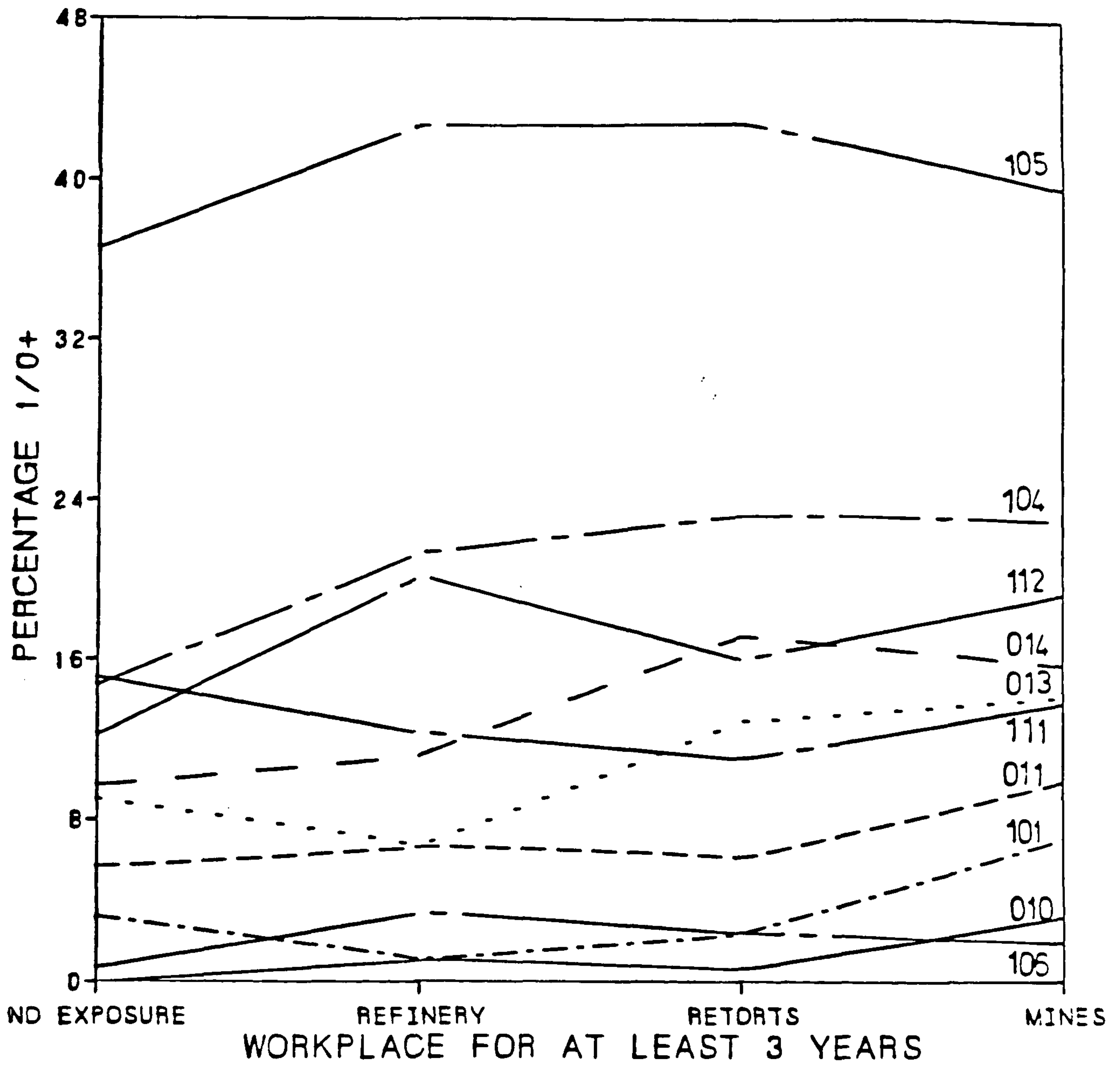


Figure 4.6: Percentage of men classified as 1/0+ by reader by workplace for irregular opacities.

Table 4.6.7

Distribution of types of opacity

Reader	No. of films read 0/0	Films read > 0/0 Rounded No.	%	Irregular No.	%
010	1154	33	46	39	54
011	913	164	52	153	48
013	670	220	39	341	61
014	873	97	27	261	73
101	246	929	94	56	06
104	552	371	55	308	45
105	487	269	36	471	64
106	1142	65	74	23	26
111	183	888	85	160	15
112	809	57	14	365	86

Table 4.6.8(a)

Percentage of men classified as 1/0+ by reader by workplace for rounded and irregular opacities

Reader	Rounded No exp.	Ref.	Ret.	Mine	Irregular No exp.	Ref.	Ret.	Mine
010	0.7	0.0	1.2	2.2	0.0	1.1	0.6	3.2
011	9.3	6.7	15.3	10.9	5.7	6.7	6.1	9.9
013	7.9	14.6	15.3	12.7	9.0	6.7	12.9	14.2
014	4.3	4.5	6.1	5.8	9.7	11.2	17.2	15.7
101	49.5	73.0	54.0	52.5	3.2	1.1	2.4	7.1
104	22.2	29.2	30.1	23.7	14.7	21.4	23.3	23.0
105	21.5	29.2	16.6	23.0	36.6	42.7	42.9	39.6
106	5.0	5.6	4.9	6.5	0.7	3.4	2.4	1.9
111	70.2	80.9	77.9	75.3	15.1	12.3	11.0	13.8
112	3.6	2.2	3.1	3.7	12.2	20.2	16.0	19.3

Table 4.6.8(b)

Percentage of men classified as 2/1+ by reader by workplace for rounded and irregular opacities

Reader	Rounded				Irregular			
	No exp.	Ref.	Ret.	Mine	No exp.	Ref.	Ret.	Mine
010	0.0	0.0	0.6	0.2	0.0	0.0	0.0	1.3
011	1.8	0.0	2.5	3.2	0.4	2.2	1.2	2.6
013	0.0	0.0	1.8	1.7	1.1	0.0	0.0	2.4
014	0.0	0.0	0.6	0.6	0.7	0.0	0.0	3.4
101	4.3	15.7	8.6	9.2	0.4	1.1	0.6	2.1
104	0.7	0.0	0.6	2.4	0.4	3.4	3.1	2.6
105	2.5	7.9	3.7	5.6	3.2	3.4	4.3	5.4
106	2.1	0.0	2.5	2.6	0.0	0.0	0.6	1.5
111	31.9	52.8	41.1	41.3	4.7	7.9	6.1	4.7
112	0.7	1.1	0.6	1.7	1.4	1.1	4.3	4.7

Shale mine dust hierarchy

A similar analysis to that described above for workplaces was done for jobs within shale mines. Each of the 521 men who had ever worked in a mine was allocated to one of four mutually exclusive groups representing the dustiest place worked at for three years or more. The percentages of men classified as 1/0+ by each reader in each of the groups - less than three years' exposure; surface dust; underground (not face); face - are shown graphically in Figure 4.7. For all the readers there is a trend of increasing profusion of small opacities with increasingly dusty jobs. However, it must be noted that most of the men (85%) worked in the two dustiest categories and only 11 men were in the 'surface' category. A strong trend was apparent also for the percentage of men classified 2/1+.

(b) Dust exposure indices

The results given thus far have been based on the concept of one workplace allocation only (dustiest workplace for greater than 3 years) for each man. In order to take each man's entire work history into account several weighting systems were

tried out, thus aiming at a "dust index" for each man. The systems that were examined were based both on knowledge of the relative dustiness of these workplaces and on comparable coalmining information. The weighting system selected was - 'no exposure' time + 2 x refinery time + 3 x retorts time + 4 x mining time. This was selected because it showed the strongest relationship between estimated dust exposure and profusion of small opacities.

One drawback of this approach to calculating dust exposure is the strong correlation between the exposure index and age (r=0.7 for the weighting system detailed above - Fig. 4.8). Because of this, the analysis has considered men within age groups. The percentages of films classified as 1/0 or more by each reader for men in the age group 61-75 are shown in Table 4.6.9 and Figure 4.9. This age range in particular was used because it contained a reasonable number of men (358) and represented a wide range of dust exposures. Some trend of increasing radiological abnormality with increasing exposure is apparent for the medical readers and for some of the non-medical panel but it must be noted that these percentages are based on small numbers of men (Table 4.6.9). Among the 770 men aged less than 60, only 66 had dust exposures greater than 20 000, so that it was not feasible to investigate any associations with increasing dust levels. The over-75 age group consisted of only 97 men, the maximum in any one dust group being 23. These small numbers made comparisons of percentages among dust groups meaningless and so no trend was detected.

The results for other weighting systems showed similar or lesser trends.

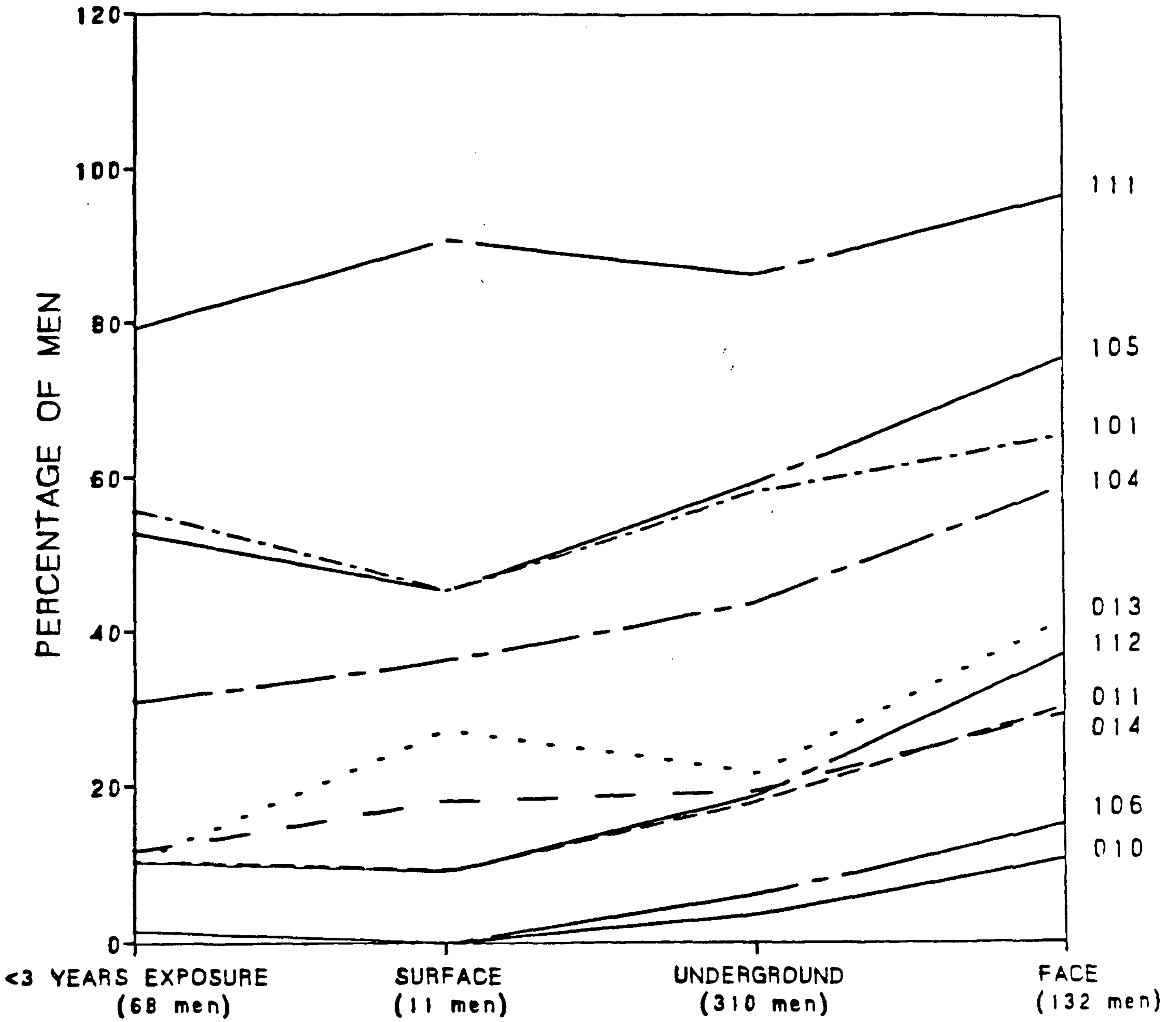


Figure 4.7: Percentage of men classified as 1/0+ by each reader for jobs within shale mines.

DUST EXPOSURE (UNITS - SEE TEXT)

70000
60000
50000
40000
30000
20000
10000
0

24 36 48 60 72 84 96

DUST V. AGE USING SYMBOL *

AGE (YRS)

Figure 4.8: Scatterplot of "dust exposure" against age for "dust exposure" (= 'no exposure' time + 2 x refinery time + 3 x retorts time + 4 x mining time). Figures represent numbers of men at each point.

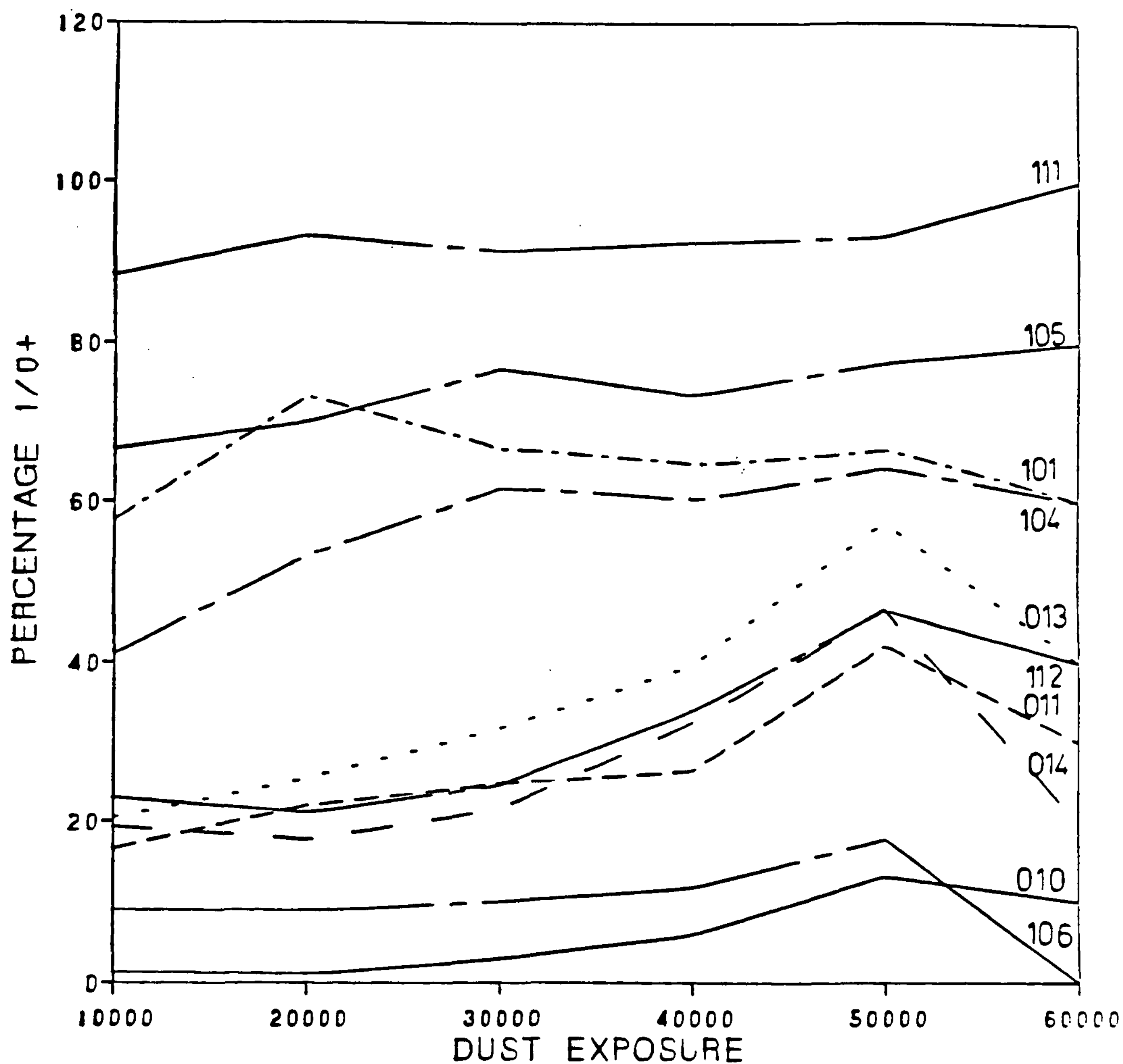


Figure 4.9: Percentage of men classified as 1/0+ by "dust exposure" for age group 61-75, for "dust exposure" (= 'no exposure' time + 2 x refinery time + 3 x retorts time + 4 x mining time).

Table 4.6.9

Percentage of men classified as 1/0+ by dust exposure for age-group 61-75

	Dust Exposure Index Group					
	0-10,000	10,001-20,000	20,001-30,000	30,001-40,000	40,001-50,000	50,001-60,000
Number of men	78	90	68	68	45	10
Reader						
010	1.3	1.1	3.0	5.9	13.2	10.0
011	16.7	22.1	24.9	26.4	42.2	30.0
013	20.5	25.5	31.8	39.7	57.6	40.0
014	19.3	17.7	21.6	32.5	46.7	20.0
101	57.8	73.3	66.6	64.7	66.7	60.0
104	41.1	53.3	61.7	60.3	64.4	60.0
105	66.7	70.0	76.8	73.5	77.7	80.0
106	9.0	8.9	10.1	11.7	17.8	0.0
111	88.5	93.3	91.3	92.6	93.3	100.0
112	23.0	21.1	24.6	33.9	46.6	40.0

(c) Formal analysis

The formal statistical modelling of the radiological results was done separately for each reader. Had similar patterns been found for all readers, an analysis of a summary statistic was to have been considered. The aim of the modelling was to assess the degree of association between the grade of pneumoconiosis of the film and the amount of shale dust exposure of the men. The information available on exposure was the numbers of years spent working in various workplaces within the shale industry and also the time spent in coalmines. These times, along with age and smoking habit (current, ex- or non-smoker) were used as explanatory variables in the analysis.

For each film two indicators were calculated for each reader, showing, first, whether it had been classified as 1/0 or more, and, second, whether it had been classified as 2/1 or more. These indicators were then used as 'y-variables' in separate logistic analyses for each reader and for each category (1/0+

and 2/1+). Because there were several explanatory variables we avoided fitting every possible subset by using a stepwise selection procedure. A stepwise logistic model selects those of the explanatory variables which are related to the probability of a particular event taking place, in this case the events being the probability of a film being classified as 1/0+ and (in a separate analysis) the probability of a film being classified 2/1+.

Tables 4.6.10 and 4.6.11 show the results from these analyses for the medical and non-medical readers. These tables detail the explanatory variables, along with their coefficients and corresponding relative risks, which are included in the 'best model' for each reader. The p-values indicate the significance of the improvement in fit of the model caused by the inclusion in each term. All terms with a p-value of less than 0.05 at each stage were included and the order of the variables in each table is the same as that in which they entered the model, thus giving an indication of the relative strengths of the different variables.

Table 4.6.10

Estimates of regression co-efficients and their associated standard errors, together with corresponding approximate relative risks and p-values. Results for medical readers

a) Classification of 1/0+

Reader Code	Variable	Coefficient	(s.e.)	Relative Risk		p-value
010	Shale mines	0.0488	(0.0149)	Per 10 yrs in shale mine	1.63	<0.0001
	Age	0.0772	(0.0222)	Per 10 yrs increase	2.16	0.0003
011	Age	0.0663	(0.0070)	Per 10 yrs increase	1.94	<0.0001
013	Age	0.0585	(0.0072)	Per 10 yrs increase	1.79	<0.0001
	Ex-smoker	-0.323	(0.1791)	Relative to current smoker	0.72	<0.0001
	Non-smoker	-0.890	(0.2152)	Relative to current smoker	0.41	<0.0001
	Shale mines	0.0185	(0.0073)	Per 10 yrs in shale mine	1.20	0.0099
014	Age	0.0503	(0.0077)	Per 10 yrs increase	1.65	<0.0001
	Ex-smoker	-0.261	(0.1905)	Relative to current smoker	0.77	0.0004
	Non-smoker	-0.937	(0.2398)	Relative to current smoker	0.39	0.0004
	Shale mines	0.0178	(0.0077)	Per 10 yrs in shale mine	1.19	0.0215

b) Classification of 2/1+

Reader Code	Variable	Co-efficient	(s.e.)	Relative Risk		p-value
010	Shale mines	0.111	(0.0252)	Per 10 yrs in shale mine	3.03	<0.0001
	Middleton Hall	0.108	(0.0415)	Per 10 yrs in Middleton Hall	2.94	<0.0001
011	Age	0.0941	(0.0151)	Per 10 yrs increase	2.56	<0.0001
013	Shale mines	0.0335	(0.0153)	Per 10 yrs in shale mine	1.40	<0.0001
	Age	0.0987	(0.0242)	Per 10 yrs increase	2.68	<0.0001
014	Shale mines	0.0641	(0.0192)	Per 10 yrs in shale mine	1.90	<0.0001
	Middleton Hall	0.0470	(0.0330)	Per 10 yrs in Middleton Hall	1.60	0.0006
	Age	0.0649	(0.0272)	Per 10 yrs increase	1.91	0.0038

Table 4.6.11

Estimates of regression co-efficients and their associated standard errors, together with corresponding approximate relative risks and p-values. Results for non-medical readers.

a) Classification of 1/0+

Reader Code	Variable	Co-efficient	(s.e.)	Relative Risk		p-value
101	Age	0.0349	(0.0049)	Per 10 yrs increase	1.42	<0.0001
	Middleton Hall	0.0389	(0.0193)	Per 10 yrs in Middleton Hall	1.47	0.0377
104	Age	0.0542	(0.0054)	Per 10 yrs increase	1.72	<0.0001
	Ex-smoker	-0.415	(0.1520)	Relative to current smoker	0.66	0.0002
	Non-smoker	-0.608	(0.1614)	Relative to current smoker	0.54	0.0002
	Coalmines	0.0459	(0.0162)	Per 10 yrs in coalmines	1.58	0.0066
105	Age	0.0533	(0.0053)	Per 10 yrs increase	1.70	<0.0001
106	Age	0.0861	(0.0107)	Per 10 yrs increase	2.36	<0.0001
111	Age	0.0625	(0.0077)	Per 10 yrs increase	1.87	<0.0001
	Ex-smoker	0.179	(0.2257)	Relative to current smoker	1.20	0.0173
	Non-smoker	-0.450	(0.1936)	Relative to current smoker	0.64	0.0173
112	Age	0.085	(0.0076)	Per 10 yrs increase	2.34	<0.0001
	Ex-smoker	-0.322	(0.1956)	Relative to current smoker	0.72	0.0041
	Non-smoker	-0.702	(0.2312)	Relative to current smoker	0.49	0.0041
	Middleton Hall	-0.0401	(0.0211)	Per 10 yrs in Middleton Hall	0.96	0.0409

b) Classification of 2/1+

Reader Code	Variable	Co-efficient	(s.e.)	Relative Risk		p-value
101	Age	0.0148	(0.0114)	Per 10 yrs increase	1.16	<0.0001
	Shale mines	0.0368	(0.0114)	Per 10 yrs in shale mines	1.44	0.0314
	Refinery	0.0393	(0.0125)	Per 10 yrs in refinery	1.48	0.0027
	Middleton Hall	0.0397	(0.0196)	Per 10 yrs in Middleton Hall	1.49	0.0306
104	Age	0.1090	(0.0169)	Per 10 yrs increase	2.97	<0.0001
105	Age	0.0809	(0.0100)	Per 10 yrs increase	2.24	<0.0001
	Coalmines	-0.0995	(0.0504)	Per 10 yrs in coalmines	0.37	0.0220
106	Age	0.1060	(0.0174)	Per 10 yrs increase	2.89	<0.0001
111	Age	0.0408	(0.0052)	Per 10 yrs increase	1.50	<0.0001
	Refinery	0.0319	(0.0098)	Per 10 yrs in refinery	1.37	0.0008
112	Age	0.0078	(0.0160)	Per 10 yrs increase	1.08	<0.0001
	Shale mines	0.0275	(0.0118)	Per 10 yrs in shale mines	1.32	0.0111

All the medical readers detected an age effect for Category 1/0+ and only one did not see a similar effect at 2/1+. For one reader, age was the only significant term in both models. For the other three readers, time spent in shale mines was strongly related at both levels and for two of them smoking had an effect on the classification of 1/0+. Additionally, two of the readers found a positive association with time spent in Middleton Hall. However, investigation of the data showed that this result was based on only two men, one of whom had also worked in a shale mine.

The non-medical readers also consistently detected an age effect at both levels and three of them saw a significant smoking effect at 1/0+. Very little association was found with shale-dust-exposed jobs at the 1/0+ level. For one reader there appeared to be an increased risk associated with years spent at Middleton Hall, while for a second reader there was a slightly decreased risk at the same workplace. Again these results could have been biased by the films of a few men. In addition, a coalmining effect was detected by a third reader. At the 2/1+ level two of the readers detected an effect of shale mining while two found an effect of time spent in refineries. The increased risk for time spent in Middleton Hall was still apparent for one reader while a further anomalous result of a decrease in risk associated with time in coalmines was seen for another reader. Both these results are likely to be due to one or two films.

In considering the individual readers' results it is apparent that it is not possible to summarise sensibly a general dust/disease relationship for the medical panel. Therefore, analyses based on a median classification for the four readers, or on the number of readers classifying a film as 1/0+, are not reported.

4.6.4 Large opacities

All films in which one or more of the ten readers recorded the presence of large opacities were reviewed by one of the authors, a chest physician. The variability of the readers in making the decision as to whether large opacities were present or not can be seen in Table 4.6.12.

Table 4.6.12

Distribution of recording of large opacities between readers

Number of films	Large opacities recorded by
39	1 non-medical
15	2 non-medical
3	3 non-medical
2	4 non-medical
3	1 medical
10	1 medical + non-medical
2	4 medical + non-medical

In reviewing these 74 films, it was apparent that the large opacities in a number of cases were clearly due to non-dust related radiographic appearances. Thus progressive massive fibrosis (PMF) could with confidence be excluded in all but 18 cases. The results of this clinical film reading are recorded in Table 4.6.13.

Table 4.6.13

Clinical reading of radiographs with large opacities	
Possible PMF	18
Healed tuberculosis (calcified)	10
Tuberculous fibrosis	5
Pleural plaques or thickening	9
Bronchiectasis	2
Thoracic surgery	3
<1cm soft nodules	3
Retrosternal goitre	1
Bone lesions, fractures	6
Elevated hemidiaphragm	1
Nipple shadow	1
Azygos lobe	1
Cardiovascular abnormalities	3
Calcified 1st costo-chondral osteophytes	3
Normal films	8

In the case of the normal films, it seemed likely that non-medical readers had mistaken overlapping rib shadows for large opacities.

All those films in which PMF could not be confidently excluded were reviewed again, this time with the occupational histories of the individuals. These films included all those in which a medical reader had recorded large opacities (15) and three of those identified only by non-medical readers. The provisional diagnoses arrived at in these films are recorded in Table 4.6.14.

Table 4.6.14

Diagnosis in possible PMF films

Film No.	Identifying readers	Work history	Clinical diagnosis
0244	4 med, 4 non-med	13 yr coal mine 9 yr shale mine	definite PMF
0314	1 med	11 yr coal mine 2 yr retorts	calcified TB
0829	1 med	37 yr refinery	rib callus
0916	1 med	25 yr refinery	inactive TB
*0860	1 med	28 yr refinery	bronchial carcinoma
*0710	3 non-med	26 yr shale mine	probable PMF
*0081	4 med	18 yr shale mine	probable TB
0922	1 med	4 yr shale mine 44 yr refinery	upper lobe TB
0149	1 med	3 yr shale mine	calcified tuberculoma
*0719	1 med	31 yr shale mine	possible TB
*0187	1 med	20 yr shale mine 23 yr refinery	probable PMF
0847	1 med	3 yr shale mine 24 yr refinery	upper lobe TB
*1192	1 med	8 yr coal mine 5 yr shale mine 28 yr refinery	possible PMF
0038	1 med	12 yr refinery	nipple shadow
0049	1 med	9 yr shale mine 11 yr refinery	rib callus
*0064	1 med	34 yr shale mine 14 yr refinery	bronchial carcinoma
*0232	1 med	5 yr shale mine 19 yr retorts & tips	probable PMF
*0243	1 med	31 yr shale mine	bronchial carcinoma

*individual's doctor contacted subsequently

In order to increase clinical confidence in these diagnoses, the individual's family doctor was contacted in nine cases. Confirmation was obtained that subjects 0860, 0064 and 0243 had subsequently died of bronchial carcinoma. Subject 0081 was known to have been treated recently for sputum positive tuberculosis. Subjects 0710, 1192 and 0187 had been investigated at Bangour Hospital on account of their X-ray reports from the survey and no active or progressive disease had been found. Subject 0232 had not been investigated as he was known to have had the radiographic abnormality previously. He remained a fit 72-year-old. Subject 0719 was known to have had a right upper lobectomy for what turned out to be shale miner's PMF.

Taking all this information into account, it was decided that PMF was present, with different degrees of likelihood, in six cases as follows:

0244 - definite: bilateral upper zone, stage B.

0719 - definite: right upper lobe, proven surgically, stage A.

0710 - probable: bilateral upper zone fibrosis and nodules, stage A.

0187 - probable: bilateral upper zone fibrosis and nodules, stage A.

0232 - probable: right upper lobe, stage A.

1192 - possible: right upper lobe, stage A or healed TB.

Of these men, two (0244 and 1192) had worked predominantly in coal mines, leaving one definite and three probable cases of PMF in men who had worked in shale, but not coal, mines. One of these men had spent more time on the surface, at retorts and tips, than underground.

4.7 Pulmonary function study

4.7.1 Introduction

This survey was carried out to determine the effect of shale workers' pneumoconiosis on lung function by comparing the lung function of shale workers with pneumoconiosis to that of shale workers without pneumoconiosis. The method of selection of cases and controls has been described in Section 3.4.5. Of the original sample of 60 cases from the 182 available men, 31 were surveyed including 25 of the 47 men classified as 1/2 or more by at least five readers. Eight men were replaced under criterion (i) - no shale exposure, and a further seven under criteria (ii) to (vi) indicating the presence of ill-health other than pneumoconiosis. The remaining 15 men either refused, were too ill to participate, or failed to provide satisfactory T_{LCO} or flow-volume measurements. Among the controls, of the original selection of 60 men, 25 took part in the survey, 20 were replaced because they had never been exposed to shale dust and six were replaced because of other illness. The remaining nine again either refused, were too ill to participate or did not complete the tests in a satisfactory way. Table 4.7.1 describes the groups in terms of age, height, weight and smoking habit. Each man was assigned to one of three smoking groups, non-, ex- or current smokers, according to criteria outlined in Section 4.5. The groups had similar distributions for all variables except weight, where the cases were in general heavier than the controls. All these variables have been allowed for in the analysis of the lung function measurements.

Table 4.7.1

Description of survey population

Group	Age	Height	Weight	Smoking Status Non	Ex	Current
	66.98*	170.39	76.92			
Cases (61)				11	18	32
	10.33	5.69	11.32			
	67.21	170.92	72.92			
Controls (61)				13	16	32
	10.57	5.42	11.01			

*Each cell contains : mean
standard deviation

No detailed matching for dust exposure was done during the selection procedure, but a division of the men by "dustiest workplace for 3 years or more" (as used in the chest radiology analysis - Section 4.6) showed a similar distribution in the two groups (see Table 4.7.2).

Table 4.7.2

Distribution of cases and controls in terms of dustiest workplace for 3 years or more

	Workplace				
	<3 Yrs Exposure	Refinery	Retort Works	Shale Mine	Total
Cases	3	3	16	39	61
Controls	2	5	20	34	61
Total	5	8	36	73	122

4.7.2 Description of data

Table 4.7.3 shows the mean values of lung function separately for cases and controls. The controls had larger mean values for all variables except RV/TLC% and this difference is statistically significant at the 5% level for FEV_1, FVC, T_{LCO} and Va. However this table takes no account of age or smoking.

Table 4.7.3

Mean lung function in cases and controls

	Cases			Controls		
FEV_1 (L)	2.37	0.71*	(59)	2.69	0.79	(57)
FVC (L)	3.64	0.80*	(59)	3.99	0.94	(58)
FEV_1/FVC %	64.7	11.5	(58)	66.3	10.3	(57)
V_{max50} (L/sec)	2.22	1.64	(54)	2.46	1.31	(55)
V_{max25} (L/sec)	0.38	0.38	(57)	0.43	0.36	(54)
Va (L)	5.58	0.99*	(53)	6.03	1.01	(57)
RV (L)	2.76	0.77	(52)	2.81	0.75	(53)
TLC (L)	6.65	0.98	(49)	6.96	0.96	(52)
RV/TLC %	41.4	8.4	(49)	40.5	9.8	(52)
T_{LCO} (ml/min/mmHg)	21.0	6.0*	(57)	24.4	5.9	(56)

Each cell is in the form = mean, standard deviation (nos. of men)

Mean age of cases = 67 s.d.10.3 years

Mean age of controls = 67.2 s.d.10.6 years

*Difference from controls significant at 5% level

Table 4.7.4 shows mean values for the groups divided by age groups. In general, and as expected, most of the variables can be seen to decrease with age within both the cases and the controls while residual volume (RV) and RV/TLC% tend to increase with age.

Table 4.7.4
Lung function by age group and case/control status

		Age Group							
		<55	56-60	61-65	66-70	71-75	76-80	81-85	>85
FEV_1	Cases	2.82	2.66	2.38	2.56	2.17	1.85	1.68	-
		0.63	0.58	0.31	0.77	0.81	0.66	0.42	-
		(12)	(7)	(7)	(10)	(7)	(10)	(6)	-
	Controls	3.55	3.14	2.68	2.58	2.48	2.08	2.06	2.76
		0.53	0.62	0.77	0.41	0.77	0.69	0.86	-
		(8)	(9)	(7)	(10)	(9)	(8)	(5)	(1)
FVC	Cases	4.26	3.91	3.75	3.86	3.30	3.25	2.71	-
		0.66	0.63	0.39	0.86	0.80	0.72	0.36	-
		(11)	(7)	(7)	(11)	(7)	(10)	(6)	-
	Controls	5.14	4.42	3.96	4.10	3.59	3.33	3.17	3.45
		0.81	0.66	0.59	0.70	0.90	0.64	1.12	0.76
		(8)	(9)	(7)	(10)	(9)	(8)	(5)	(2)
T_{LCO}	Cases	24.95	25.14	20.06	22.50	18.16	16.32	16.10	-
		6.37	4.64	4.37	5.24	5.00	3.80	5.52	-
		(12)	(7)	(6)	(11)	(7)	(9)	(5)	-
	Controls	28.74	27.00	21.09	24.22	25.30	21.75	21.05	17.07
		4.44	4.84	6.00	6.74	4.30	6.29	5.15	-
		(8)	(9)	(7)	(10)	(9)	(7)	(5)	(1)
V_{max50}	Cases	2.86	3.36	1.98	1.68	2.95	1.22	1.20	-
		1.77	2.32	0.88	1.24	1.90	0.98	0.50	-
		(12)	(7)	(7)	(8)	(6)	(9)	(5)	-
	Controls	3.46	3.05	2.91	2.06	2.12	1.83	1.63	2.19
		1.28	1.47	1.61	1.01	1.23	0.90	1.01	1.31
		(8)	(8)	(7)	(11)	(7)	(7)	(5)	(2)
V_{max25}	Cases	0.57	0.50	0.27	0.33	0.37	0.17	0.39	-
		0.51	0.35	0.24	0.42	0.28	0.21	0.36	-
		(12)	(7)	(7)	(10)	(6)	(9)	(6)	-
	Controls	0.70	0.75	0.62	0.25	0.23	0.26	0.23	0.39
		0.27	0.47	0.44	0.23	0.20	0.15	0.24	0.04
		(6)	(9)	(7)	(11)	(8)	(6)	(5)	(2)
Va	Cases	6.03	5.85	5.41	5.67	5.00	5.53	4.91	-
		0.93	0.99	0.73	0.96	1.28	0.97	0.87	-
		(12)	(7)	(5)	(10)	(6)	(8)	(5)	-
	Controls	6.84	6.35	5.94	6.23	5.86	5.31	5.36	4.92
		1.17	0.93	0.54	0.95	0.87	0.93	1.04	-
		(8)	(9)	(7)	(11)	(9)	(7)	(5)	(1)
RV	Cases	2.46	2.63	2.81	2.82	2.78	3.17	2.99	-
		0.94	0.59	0.26	0.65	0.56	1.04	1.24	-
		(12)	(7)	(6)	(11)	(6)	(6)	(4)	-
	Controls	2.21	2.90	3.30	2.95	2.50	2.93	2.95	2.35
		0.60	0.65	1.06	0.75	0.57	0.78	0.46	0.40
		(7)	(9)	(7)	(10)	(7)	(6)	(5)	(2)
TLC	Cases	6.73	6.74	6.58	6.87	6.32	6.59	6.23	-
		1.19	0.91	0.48	0.93	1.18	1.03	1.53	-
		(10)	(7)	(6)	(11)	(6)	(6)	(3)	-
	Controls	7.27	7.50	7.47	7.04	6.40	6.61	6.37	6.02
		1.13	1.11	0.64	0.85	1.06	0.65	0.70	0.29
		(7)	(8)	(7)	(10)	(7)	(6)	(5)	(2)
RV% / TLC	Cases	36.43	38.83	42.66	41.12	44.32	47.35	45.32	-
		8.66	5.80	2.29	8.53	6.63	9.76	15.35	-
		(10)	(7)	(6)	(11)	(6)	(6)	(3)	-
	Controls	30.36	39.15	43.75	42.00	39.36	44.28	46.98	39.30
		6.47	5.16	11.69	10.08	8.13	11.13	10.96	6.51
		(7)	(8)	(7)	(10)	(7)	(6)	(5)	(2)
FEV% / FVC	Cases	66.95	68.45	63.80	66.60	64.18	55.99	68.91	-
		12.53	10.31	7.79	7.15	15.91	13.04	8.36	-
		(11)	(7)	(7)	(10)	(7)	(10)	(6)	-
	Controls	69.57	70.84	66.97	63.34	68.04	60.37	63.47	69.17
		7.25	8.23	15.36	7.79	7.67	13.73	12.02	-
		(8)	(9)	(7)	(10)	(9)	(8)	(5)	(1)
Ht. (cm)	Cases	171.92	171.00	173.86	171.54	166.00	168.45	169.17	-
		6.37	3.00	2.54	6.58	5.38	6.02	4.87	-
		(12)	(7)	(7)	(11)	(7)	(11)	(6)	-
	Controls	172.78	171.56	172.00	170.54	169.22	171.00	168.60	170.00
		7.03	6.23	4.93	5.92	4.29	5.48	4.09	4.24
		(9)	(9)	(8)	(11)	(9)	(8)	(5)	(2)
Wt. (kg)	Cases	80.83	75.29	80.71	80.73	71.14	73.09	73.33	-
		15.76	8.84	13.96	10.10	7.65	6.65	10.61	-
		(12)	(7)	(7)	(11)	(7)	(11)	(6)	-
	Controls	73.67	74.00	67.25	69.73	76.11	74.75	74.80	69.50
		10.02	7.78	10.83	13.73	7.47	9.21	19.63	2.12
		(9)	(9)	(8)	(11)	(9)	(8)	(5)	(2)

Each cell contains : mean
standard deviation
(number of men)

The case-control differences found in the overall comparison were maintained in the age breakdown. For FEV_1, FVC and T_{LCO} the values for the controls were greater than those of the cases in all age groups and other variables (V_{max50},FEV_1/FVC%,Va) have larger values for controls in all but a few age groups. The remaining three lung function measurements show no consistent pattern. For V_{max25} the values for the controls were larger in the three youngest age groups (<65) and smaller for three of the four older ages, the exception being between 76 and 80. The mean control RV was larger than that of the cases for ages 56 - 70 and smaller for all other groups. The differences in levels of RV/TLC% fluctuated in both directions with no discernible trend.

Height remained similar in all age groups but the large difference in weight was maintained. For the older ages 76 - 85, and additionally for ages 56 - 60, the weights were similar but for all other ages the controls were lighter. It should be noted that many of the differences commented on above are of small magnitude and that there are small numbers of men in the groups.

4.7.3 Analysis and results

The formal statistical analysis of the data used standard multiple linear regression techniques to allow for the effects of age, height, weight and smoking. Preliminary exploratory analysis showed that the rate of loss of lung function with age was different for the cases and the controls, and for some variables, the effect of smoking was different in the two groups. Where necessary, these effects were also allowed for in the analysis. Therefore the fitted model included terms for age (separately for cases and controls), height and weight. Because of the dependence on age, the results are tabulated at two different ages, 60 and 75 years (Table 4.7.5).

These results show the values predicted from the model for a non-smoking man of average height and weight. It can be seen that predicted values for FEV_1, FVC, T_{LCO}, V_{max50}, RV and TLC were lower in cases than in controls and, except for RV and T_{LCO} the differences diminished at the older age. Conversely, V_{max25} and Va were higher in cases than in controls, these difference also lessening in older men. The only case-control differences of these not to attain significance were those for RV and FEV_1/FVC.

Table 4.7.5
Fitted values for non-smokers at two ages for 10 lung function variables

	Age 60		Age 75	
	Cases	Controls	Cases	Controls
FEV_1	2.66	3.10	2.22	2.44
FVC	3.81	4.41	3.22	3.69
FEV_1/FVC%	70.79	70.51	67.77	65.68
T_{LCO}	24.28	27.95	20.16	24.55
V_{max50}	3.26	3.54	1.66	1.00
V_{max25}	0.79	0.59	0.45	0.34
Va	7.51	6.24	4.63	5.86
RV	1.96	2.14	2.04	2.61
TLC	5.66	6.90	5.70	6.53
RV/TLC%	33.90	31.35	36.82	39.78

In order to illustrate the effects of smoking on these results, the case-control differences predicted by the model are tabulated in Table 4.7.6 separated into non-, ex- and current smokers at the two ages. In the cases of FEV_1, FVC and T_{LCO}, smoking status did not alter the predicted case-control differences. An effect was noted for FEV_1/FVC and V_{max50} differences (greater in smokers) and Va, RV and TLC (differences smaller in smokers).

Table 4.7.6

Case-control differences in fitted values at two ages for three smoking groups (controls-cases)

	Age 60			Age 75		
	Non	Ex	Current	Non	Ex	Current
FEV_1	0.44	0.44	0.44	0.22	0.22	0.22
FVC	0.61	0.61	0.61	0.47	0.47	0.47
FEV_1/FVC	-0.28	6.94	3.22	-2.09	5.13	1.36
T_{LCO}	3.67	3.67	3.67	4.39	4.39	4.39
$V_{max}50$	0.28	0.92	0.39	0.13	0.78	0.24
$V_{max}25$	-0.20	0.35	0.25	-0.11	-0.74	0.002
Va	1.28	0.46	0.35	1.03	0.21	0.11
RV	-0.18	-0.23	0.05	0.57	-0.80	-0.03
TLC	1.24	-0.21	0.35	0.82	-0.63	-0.07
RV/TLC	-2.55	-3.55	-0.99	2.96	-7.71	0.08

These results may be summarised as showing that men with pneumoconiosis had in general a reduction in both FEV_1 and FVC, together with a lowered gas transfer factor and lung volumes. The mean transfer coefficient (T_{LCO}/Va) of the cases (3.77) was lower than that of the controls (4.04), suggesting that the lowered T_{LCO} was not entirely due to restriction of lung volumes.

4.7.4 External comparisons

In considering a population as elderly as the ex-shale workers, comparison with external 'normal values' is of doubtful validity since these reference values are based largely on younger men. Nevertheless, in order to illustrate the results in a way which will be familiar to clinicians, we have also expressed them in terms of percentage of two well-known sets of predictive equations, those of the European Community (CEC)[13] and of Cotes.[14] Tables 4.7.7 and 4.7.8 show the overall results according to these two standards. The results are unchanged in that again significant differences between cases and controls were found for FEV_1, FVC and T_{LCO}. Looked at clinically, these average results would be taken to indicate a mild obstructive

pattern with reduced transfer factor in cases whereas controls would be regarded as normal. Further analyses using percentage of predicted values in terms of smoking status and age effect showed no important differences from those found in the internal analyses.

Table 4.7.7

Percent predicted values (CEC) : Mean ±S.D.

	%FEV_1	%FVC	%FEV_1/FVC	%T_{LCO}	%V_{max50}	%V_{max25}	%RV	%TLC	%RV/TLC
Cases	81.79*	97.47*	86.07	81.40*	53.76	28.13	112.77	101.82	105.37
	22.13	17.92	15.10	18.46	38.88	29.26	29.70	13.56	19.46
Controls	91.53	105.59	88.22	95.10	60.19	31.33	113.08	105.23	101.11
	22.87	19.19	13.43	21.03	30.65	24.30	30.73	11.74	22.61

Each cell contains : Mean
S.D.

*Difference between cases and controls significant at 5% level.

Table 4.7.8

Percent predicted values (Cotes) : Mean ±S.D.

	%FEV_1	%FVC	%FEV_1/FVC	%T_{LCO}	%V_{max50}	%V_{max25}	%RV	%TLC	%RV/TLC
Cases	88.28*	95.93*	96.69	84.25*	46.19	23.31	121.25	105.92	106.28
	23.80	17.71	17.28	18.99	33.32	24.03	31.25	14.14	19.60
Controls	98.94	104.04	99.11	98.47	51.68	26.14	121.63	109.28	102.21
	24.52	19.28	15.26	21.79	26.34	19.79	32.86	12.04	22.88

Each cell contains : Mean
S.D.

*Difference between cases and controls significant at 5% level.

4.7.5 Influence of respiratory symptoms on result

Each man who took part in the lung function survey also answered a questionnaire (based on that of the British Medical Research Council[10]) on respiratory symptoms (Appendix 7.12). Subjects were separated according to their answers into groups with chronic cough and sputum, chest illness, and breathlessness as defined in Table 4.7.9. The frequencies of these symptom complexes are recorded in Table 4.7.10. Two men were unclassifiable in terms of cough and sputum because of invalid answers.

While cough and sputum appeared equally in cases and controls, chest illness and breathlessness were significantly more common in cases ($p<.05$). The overall prevalence of symptoms was higher among cases (53%) than controls (30%) and more cases had two or more symptom complexes (47%) than did controls (28%). These results are recorded in Tables 4.7.10 and 4.7.11.

The cases (shale workers with pneumoconiosis) and controls (shale workers without pneumoconiosis) were divided into those with chronic cough and sputum (bronchitics) and those without (non-bronchitics). Table 4.7.12 records their lung function, expressed in terms of percentage of CEC predicted.[13] In the non-bronchitic group, cases had worse lung function than controls and the previously demonstrated pattern of reduced FEV_1, FVC and flow rates and transfer factor was apparent. There were only relatively small numbers of bronchitics, but it was clear that the bronchitic controls and cases had very similar lung function, with reduced FEV_1, FVC and flow rates and raised residual volume. Bronchitis cases appeared to differ from controls in having considerably lower transfer factor. Lung function of bronchitics in general was worse than that of non-bronchitics, the values of bronchitic controls usually being worse than those of non-bronchitic cases.

Table 4.7.9

Prevalence of symptoms : Lung function men in shale survivor study

Definition of symptoms

1. Chronic bronchitis

YES to Q2, Q4, Q6 and Q8 where:

Q2 = Do you cough when you get up, or first thing in the morning on most days for as much as 3 months in the year?

Q4 = Do you cough during the rest of the day on most days for as much as 3 months in the year?

Q6 = Do you bring up phlegm when you get up first thing in the morning on most days for as much as 3 months in the year?

Q8 = Do you bring up phlegm during the rest of the day on most days for as much as 3 months in the year?

2. Chest illness

YES to Q12 where:

Q12 = In the last 3 years have you had a chest illness that has kept you from your usual activities for as much as a week?

3. Breathlessness

YES to Q9 or Q10 where:

Q9 = Do you have to walk slower than other people on level ground because of your chest?

Q10 = Do you ever have wheezing or whistling in your chest? I don't mean only when you have a cold.

Table 4.7.10

Frequency of respiratory illness in cases and controls

		Cases	Controls	Total
Chronic cough and sputum	No. of men	6	6	12
	(%)	(10)	(10)	(10)
Chest illness	No. of men	12	3	15
	(%)	(20)	(5)	(12)
Breathlessness	No. of men	30	14	44
	(%)	(49)	(23)	(36)

Table 4.7.11

Combinations of symptoms in cases and controls

Bronchitis	Chest Illness	Breathlessness	Cases	Controls	Total
Y	Y	Y	1 (2%)	0	1 (2%)
Y	Y	-	0	0	0
Y	-	Y	4 (7%)	4 (7%)	8 (7%)
-	Y	Y	10 (17%)	1 (2%)	11 (9%)
Y	-	-	1 (2%)	2 (3%)	3 (2%)
-	Y	-	1 (2%)	2 (3%)	3 (2%)
-	-	Y	15 (25%)	9 (15%)	24 (20%)
-	-	-	28 (47%)	42 (70%)	70 (58%)

Y = Yes

Table 4.7.12

Mean percent predicted values (CEC) for cases and controls separated by presence/absence of chronic cough and sputum

	Non-bronchitics		Bronchitics	
	Cases	Controls	Cases	Controls
FEV_1	83.6* 21.8 (52)	94.4 21.3 (51)	64.7 20.4 (5)	63.3 23.7 (5)
FVC	98.6 17.8 (52)	108.0 18.6 (51)	86.5 18.0 (6)	85.3 14.0 (6)
$FEV_1/FVC\%$	87.1 14.8 (51)	89.4 12.4 (51)	76.5 16.5 (6)	76.7 20.8 (5)
$V_{max}50$	57.0 39.7 (47)	62.6 31.4 (49)	27.6 24.0 (6)	37.4 12.4 (5)
$V_{max}25$	29.9 30.4 (50)	31.8 24.8 (48)	13.2 16.1 (6)	23.9 21.0 (5)
RV	109.7 29.01 (46)	111.6 31.02 (46)	134.8 29.4 (5)	125.5 31.3 (6)
TLC	101.4 13.2 (43)	105.6 11.9 (45)	101.5 16.2 (5)	102.7 12.4 (6)
RV/TLC	103.1 19.0 (43)	99.3 22.6 (45)	124.1 15.8 (5)	115.6 21.0 (6)
T_{LCO}	83.2 17.8 (50)	95.2 20.6 (50)	63.5 14.3 (6)	92.1 29.5 (5)

* Each cell is in the form : Mean
Standard Deviation
(No. of men)

Finally, a term denoting the presence or absence of chronic cough and sputum was included in a regression analysis similar to that described in Section 4.7.3. The influence of cough and sputum was considered separately for cases and controls to determine whether it affected the two groups differently. The results showed that its effect was slightly less severe in cases than in controls but the differences were all small in magnitude and none reached statistical significance. Therefore the results for all men together are given in Table 4.7.13. The co-efficients in this table denote the change in lung function in bronchitics compared to non-bronchitics. It can be seen that levels of FEV_1, FVC and FEV_1/FVC were lower in bronchitics while RV and RV/TLC were higher, all with t-values suggesting that the differences were unlikely to be due to chance.

Table 4.7.13

Difference in lung function levels for men with chronic bronchitis

	Difference in Level	t-value
FEV_1(L)	-0.68	-3.38
FVC (L)	-0.57	-2.72
FEV_1/FVC (%)	-9.23	-2.80
T_{LCO} (ml/min/mmHg)	-2.27	-1.56
V_{max50} (L/sec)	-0.82	-1.86
V_{max25} (L/sec)	-0.13	-1.14
Va (L)	-0.48	-1.79
RV (L)	0.48	2.29
TLC (L)	-0.09	-0.38
RV/TLC (%)	7.74	2.94

CHAPTER 5
DISCUSSION

5.1 Background and objectives

The mining industry has always been regarded as hazardous. In the first century AD, Pliny the elder described the dangers of fumes to which miners were exposed, while Agricola in 1556 gave an account of the fatal effects of dust inhalation.[15] By the end of the eighteenth century silicosis had been recognised as an important and fatal hazard of workers who cut stone, and this disease was given appropriate prominence in the first great English language book on occupational disease, Thackrah's "The effects of the principal arts, trades and professions and of civic states and habits of living on health and longevity", published in 1831. Thus, by the time of the start of the Scottish shale oil industry in the 1850s and 1860s, miners and their employers may well have known something of the pulmonary hazards of the industry as well as of those due to accidents and explosions. However, the first indication of serious health hazards in the industry came from what must have been an unexpected quarter. Cancer in the last century was not the common problem that it is today, most people dying of infections rather than degenerative diseases, tuberculosis being the main killer. Cancer in relation to occupation had been described as early as 1775 when Pott recorded the occurrence of skin and scrotal cancers in chimney sweeping boys,[5] who were heavily exposed to soot from burnt coal. It is likely that this observation followed shortly after the widespread introduction into London of canal-borne coal from the English Midlands in place of the less carcinogenic wood and coal from the North-East of England. The appearance of cancer of the skin and scrotum in workers producing paraffin from shale was a sufficiently striking event for it to have been recorded by Bell in 1876,[3] only 20 or so years after the start of the shale oil industry. This

was one of the earliest causes of cancer to have been described, preceeding those of bladder cancer in aniline dye workers in 1895,[16] and of lung cancer in miners exposed to radiation in Schneeberg in 1879.[17] Moreover, it provided Scott, a general practitioner in the oil shale area of Scotland, with the opportunity for some pioneering work in the epidemiology and prevention of skin cancer and the pre-cancerous and benign skin lesions of the workers.[18] This work appeared to have been successful in that skin and scrotal cancer became rarities in the shale industry within his lifetime.

So far as can be ascertained, the Scottish shale miners were spared the degree of hazards to which their close neighbours, the coalminers, were exposed. Explosions and problems with gas were probably relatively uncommon, the shale mines not being very much subject to methane accumulation and the shale dust apparently not constituting a serious explosive risk. Even pneumoconiosis, which was well recognised in coalminers in the early twentieth century in Britain, was not described in shale miners during the lifetime of the industry. It seemed, therefore, that the last chapter in the story of shale workers' diseases might have been written when progressive massive fibrosis, or complicated pneumoconiosis, was described in four ex-shale miners in 1981,[8] twenty years after the Scottish industry finally closed. This disease occurred in men who had spent a lifetime mining shale and, from the pathological and mineralogical findings in the lungs, it seemed likely that it was a specific pneumoconiosis of shale miners rather than being silicosis. The finding of peripheral squamous lung cancer in two of these four men, though possibly coincidental, suggested that such scar cancers could also have been a potential hazard of shale miners.

A renewed interest in shale as an alternative source of oil in the United States has put these episodes of industrial medical

history in a new light.[1,2] With the reasonable likelihood of a major shale oil industry developing in the Rocky Mountains before the end of the 20th century, it has become important to re-examine the hazards of the defunct Scottish shale industry in order to plan their elimination, or at least reduction, in the future American workforce. The present studies were thus planned to obtain the maximum amount of information on health risks from what, at first, appeared a rather unpromising source, the records of the defunct Scottish shale oil industry.

The specific objectives were two-fold. The first was to carry out a mortality study of the workforce, and this is described and discussed in Volume 3. The second, described in this volume, was to identify surviving shale workers, to ascertain the prevalence and functional effects of pneumoconiosis among them, and to describe their reported prevalence of skin disease and of tobacco smoking. In order to achieve these twin objectives, it was necessary to identify a listing of employees in the industry. The finding of the Provident Fund, with its associated application form (the P-form), was a considerable stroke of good fortune which allowed this unique study to proceed; the P-forms not only provided an almost complete list of industrial workers employed by the sole shale oil company in 1950 (Scottish Oils Ltd.) but also gave in each case an accurate and comprehensive occupational history up until the man's time of joining the Fund. Careful checks have validated the accuracy of these histories, while many interviews with the men themselves and with others familiar with the industry have allowed a picture to be built up of what the different jobs entailed, including likely relative levels of exposure to industrial dusts and pollutants. The only thing that has not become available has been any record of actual measurements of airborne dust or fume and it seems probable that these were rarely, if ever, made.

5.2 Response rate in study of ex-shale workers

An important problem in epidemiological studies arises from the investigators' inability to examine the entire target population or an appropriate sample of it. In an investigation of workers from an industry which closed 20 years previously, it would be anticipated that many of the workforce would have died and that these men would inevitably have been older and iller than those who survived. Fortunately, it has proved possible to take some account of this in the present study by carrying out the concurrent mortality study (Volume 3). Furthermore, in any study of an elderly group of ex-workers, it was to be anticipated that a number would be unwilling or unable to take part and that others would be unable to be traced. Again this proved to be the case and, in spite of the elaborate and persistent methods employed, only 1 664 of the 3 566 men identified as alive (46.7%) actually took part in the surveys and 1 231 of these were selected for the radiological investigation. Clearly there is a risk that the men who did not take part were in some way more ill, or had been exposed to greater hazard at work, than those who did respond, and this might have introduced a serious bias into the results. It was reassuring, therefore, to find that the age distributions of responders and non-responders were virtually identical. Moreover, it was not possible to demonstrate any serious bias in terms of selection of men from more or less hazardous occupations. Nevertheless, it remains possible, and is indeed likely, that the men examined represented a somewhat healthier group than those who were not (some of whom were reported to be in hospital), and to this extent any conclusions drawn from this study should be interpreted in the knowledge that they are likely to represent an underestimate of disease prevalence.

5.3 Skin disease in ex-shale workers

As discussed above, skin disease and skin cancer were well-known hazards of workers exposed to shale oils in the early years of the industry, but it seems likely that the incidence of these conditions was much reduced in the mid-20th century by the work of Scott[18] and the introduction of appropriate hygiene measures and workforce surveillance. In this study an attempt has been made to ascertain the prevalence of a number of skin diseases in the ex-shale workers by means of a cross-sectional questionnaire study. It should be noted that no clinical examinations of individuals or their skins were made and the validity of the questionnaire has not been tested in terms of what positive answers to the various questions mean with respect to actual clinical findings. Nevertheless, it may be assumed that positive answers to questions about "skin tumours or cancer" would indicate a high probability that the respondent had indeed suffered from that condition. It was interesting, therefore, to find that shale workers in general, and those exposed to dust or oil in particular, had no higher a prevalence of probable skin tumours than did either of the control groups. These control groups were composed of other shale workers, not exposed to dust and oil and, since these men might have had a greater exposure than shale miners to the known skin carcinogen, sunlight, of coalminers of similar age to the shale workers. Moreover, wherever differences in the prevalence of skin disease between shale workers and coalminers were found, these were always in the direction of being greater among the coalminers, a group of workers known to be at increased risk of benign skin disease.[19] If anything, it seems intuitively more likely that a man with a history of skin disease would have returned the questionnaire than would a man without such a history, and therefore it is reasonable to conclude that in the latter years of the Scottish industry there was not an increased risk of skin

cancer amongst the dust- and oil-exposed men. This conclusion assumes that skin cancer was not an important cause of mortality, a matter discussed further in Volume 3.

5.4 Smoking habits of ex-shale workers

One objective of the survey of smoking habits of shale workers was to obtain information of value in interpreting the mortality results, and this is discussed further in Volume 3. In addition, however, the results have been used in the analyses of the radiological and lung function surveys. The overall finding, that 51 per cent of those who responded to the questionnaire were current smokers, 26 per cent ex-smokers and 23 per cent life-long non-smokers was evidence of a slightly lower prevalence of smoking than in a comparable group of Scottish coalminers of similar age distribution. It is open to speculation how far this result is due to selection effects, since smokers may well have been less ready to return the questionnaire than non-smokers, while the information from coalminers was obtained by clerks at surveys where the response rates had been somewhat higher (around 70%) than in the study of ex-shale workers. Even so, the results are in keeping with the known heavy smoking habits of industrial populations in Scotland in that 77 per cent of respondents had at some time been smokers, the majority admitting to having smoked more than 10 cigarettes daily.

5.5 Pneumoconiosis in ex-shale workers

Radiological surveys of dust-exposed populations are subject to well-known problems of interpretation. In particular, there may be considerable difference of opinion as to the presence and category of pneumoconiosis between readers, even when these readers are experienced in the use of the ILO standard classification. Moreover, these differences of opinion become pronounced when decisions are required as to

the size and shape of opacities recorded.[20] Finally, it should be recognised that small opacities on the chest radiograph may be caused by conditions other than pneumoconiosis. Small irregular opacities seem to be a feature of the radiograph of older subjects and have been shown to occur increasingly frequently in relation to the subject's age and to symptoms of bronchitis.[21] Similar irregular shadows have also recently been shown to be related to dust exposure in coalminers.[22]

Bearing these points in mind, it was decided to analyse the results in terms of prevalence of opacity recorded, without differentiating between the different types of opacity (p,q,r,s,t,u) in the ILO classification.[11] Furthermore, the use of only one or two readers, no matter how expert or well-trained, would have the potential to produce seriously misleading results as to prevalence of pneumoconiosis, depending on their particular bias towards reading 'high' or 'low'. In this study a large number of readers, both medically qualified and para-medical, has been used and the results of each recorded individually. It has thus proved possible to investigate the ability of each reader to detect the influences of dust exposure, age and cigarette smoking on the prevalence of radiographic opacities and, while noting the considerable differences between readers, nevertheless show that most were able to detect effects that validated their readings. Further validation of the radiological results is discussed in Section 5.6.

Perhaps the most striking result of the radiological survey was the low prevalence of high categories of pneumoconiosis among the miners and retort men. Nevertheless, there is little doubt that radiological opacities may be found more frequently in men who have worked for longer periods in dustier areas. This was most apparent when Category 2/1 was considered; although all readers detected early changes in a

proportion of men who may be assumed to have had little or no dust exposure, a clear trend was found by most of them of increasing prevalence of 2/1+ opacities with increasing likelihood of exposure to shale mine dust. Most of the readers, including all four medical ones, found a similar trend with Category 1/0+ films. Further investigation of this in the medical readers shed some light on the differences in reading level between them. Using multiple regression techniques and considering Category 1/0+, it was possible to show that one reader (010), whose full-time job involved reading films of coalminers and other dust-exposed workers, was able to detect age and dust-related effects, but did not apparently pick up smoking-related effects. Two of the readers (013 and 014), primarily clinical chest physicians and authors of this report, seemed to read "higher" and in doing so detected dust, age and smoking effects, while the fourth, also a chest physician, seemed to detect the age effect but not the other two. When Category 2/1+ readings were analysed similarly, no reader detected a smoking effect but again age, in three cases, and shale mine exposure, in three cases, were picked up. Apparently, in spite of using the same standard films and working to the same rules, experienced readers may detect different, though equally valid, abnormalities on chest radiographs when these abnormalities are predominantly low (below Category 2/2) on the twelve-point ILO scale.

Analysis of the readings of the non-medical readers also showed a clear age effect, but in general it seems that the much higher level of recording small opacities obscured the shale and smoking effects found by the medical readers.

The findings with respect to progressive massive fibrosis (PMF) were equally interesting. Two definite, three probable and one possible cases were detected among the 1 231 men, (629 of whom had been exposed to dust) and two of these had worked mainly as coalminers. The lack of unanimity between readers

in the recording of large opacities was particularly striking and it was for this reason that a quasi-clinical approach was used in making the diagnosis of PMF. The non-medical readers, as expected, recorded all large opacities that they observed and it proved possible to exclude the possibility of PMF on radiological grounds in many of these. Nevertheless, most of the films recorded as showing large opacities did indeed have some abnormality, indicating that the non-medical readers were being careful to adhere to their protocol. In contrast, the medical readers had a clear tendency to make other diagnoses on the radiological appearances and not record large opacities when they thought the lesion was not PMF. This is presumably the explanation of why, of the final list of six probable or possible cases, only one had been recorded by more than one medical reader, and one had in fact been recorded by no medical reader but by three non-medical readers. The procedures used in this study, epidemiological reading by 10 readers, followed by a clinical study of films, occupational histories and doctors' records makes it likely that very few, if any, cases of PMF will have been missed.

Thus it seems likely that PMF was, as suspected, relatively rare in the shale industry. Of the four non-coalminers with probable disease, one has already been described in the literature as the first shale miner found to have PMF.[8] Two of the others had irregular and nodular upper lobe fibrosis with loss of lobar volume, a feature associated sometimes with high exposures to quartz;[23] whether these two men had such exposures is not known. The remaining man had worked underground only for five years but had subsequently worked in in dusty conditions on retorts (7 years) and tipping spent shale on bings (11 years). His radiological appearance of soft upper zone A shadows was very similar to that of the first described patient.[8]

The frequency with which such advanced pneumoconiosis was found in shale miners and retort workers is apparently less than that found in many coalminers of the same era. In Britain and USA a high prevalence of pneumoconiosis has been associated with high rank (highly combustible, high carbon) coal exposure, but lower prevalences occur in collieries in which the coal dust has a higher ash content.[24,25] The findings in shale workers are reminiscent of the latter type of coalmine exposure, where it has been suggested that other minerals or metallic ions may interfere with the toxicity of quartz and other harmful substances.[26] As pointed out in a previous publication,[8] the mineralogy of shale and of low-rank coal dust is not very dissimilar. The results of our comparisons of Scottish and US shales reported in Volume 1 have shown the ash and quartz contents to be similar in percentage terms. However, the US shales contain smaller amounts of the minerals kaolinite and mica that are thought to have this protective effect. It may be therefore that US shale would have a greater tendency to cause silicosis than Scottish shale. This remains speculative, although appropriate in-vivo toxicological comparisons might shed some light on the problem.

In summary, high categories of pneumoconiosis (2/1+) appear to to have been found in between 1.6 and 5.8% of miners and 0.6 and 3.6% of retort workers, depending on the reader (see Table 4.6.6). PMF occurred in about one per cent of miners and retort workers, in some of whom coal exposure had probably contributed. A relationship of pneumoconiosis to dust exposure estimates has been demonstrated and the difficulties in interpretation due to additional effects of age and smoking on the chest radiograph has been noted.

5.6 Lung function in relation to radiological abnormalities

An objective of the research was to investigate any

physiological effects that might be attributable to pneumoconiosis in shale miners. It is generally accepted that simple coalworkers' pneumoconiosis per se does not cause important alterations in pulmonary function, though minor mechanical abnormalities suggestive of disease of small airways in high categories of simple pneumoconiosis,[27] and a raised residual volume[28] and slight reduction of gas transfer factor[29] in certain circumstances have been described. In addition, recent studies have shown that small irregular opacities may be a feature of coalworkers' pneumoconiosis,[30] related to dust exposure,[22] and may be associated with emphysematous changes in the lungs post-mortem.[31] In the present study, a case-control approach has been used, in which cases were defined as men with at least Category 1/1 simple pneumoconiosis (as agreed by at least five readers), all of whom had been exposed to shale dust and none of whom had any other obvious clinical cause of pulmonary opacities. Controls were selected on the basis of having radiographs showing Category 0/1 or less, agreed by at least eight readers, and their selection was stratified in order to match the age distribution of the cases. They also had been exposed to shale dust and, as it turned out, the distribution of their dust exposure in terms of "dustiest workplace for 3 years or more" was very similar to that of the cases. In view of the good matching of cases and controls in terms of age and occupational exposure history, it was perhaps surprising that such clear-cut differences were found between them in terms of lung function. It seems not unreasonable to attribute these functional abnormalities to whatever pathological change is also responsible for the radiological changes. In other words, it seems likely that pneumoconiosis in shale workers is associated with functional abnormalities to an extent greater than has previously been recognised in coalminers. It should also be noted that the finding of these abnormalities in turn provides convincing validation of the radiological readings. There are, however, two important

provisos. First, it is possible that the radiological changes and the physiological abnormalities are both independent effects of the same cause, inhalation of shale mine dust and fume. Thus it may be that two separate pathological effects follow shale dust and fume inhalation, one leading to a benign condition that causes radiological changes and the other leading to alveolar and airway damage, causing functional impairment. Such appears to be the case in coalminers, where pneumoconiosis and emphysema, though often combined in the same individual, seem to be independent effects of dust inhalation.[32] Although our cases and controls were roughly matched in terms of occupational exposures, it is not possible to be confident that this alternative explanation has been excluded. Second, it is possible that in this elderly group of men the readers selected all those with radiological changes of whatever sort, including many in whom the changes were not due to dust exposure. It is not possible to exclude this with certainty; however a clinical review of the films was carried out and this did not reveal large numbers of men with radiographic disease other than that likely to be due to dust exposure. Two films showed evidence of cardiac failure, four showed some interstitial fibrosis (which could of course be dust-related), one showed old upper lobe tuberculosis and one showed extensive bronchiectasis. The rest showed generally a low category of simple pneumoconiosis, considered by the reader (Dr. Seaton) to be predominantly of p or s types.

It therefore seems likely that workers who were exposed to shale dust ran a small but definite risk of pneumoconiosis and that when they developed it, they were likely to show a reduction in pulmonary function. The pattern of this functional abnormality is an interesting one, in that it appears to have caused reduction in FEV_1, FVC, respiratory flow rates and transfer factor, without appreciable increase in residual volume. This is somewhat different to the

well-described effect of cigarette smoke, which includes an increase in residual volume, and it suggests a lesion about the terminal bronchi and respiratory bronchioles, with a mixture of fibrosis (causing some restriction) and either airway narrowing or emphysema or both (causing the airways obstruction). This pattern is very similar to that described in recent studies of coalminers with irregular opacities,[33] and supports the suggestion from Estonia that pulmonary fibrosis may occur in shale miners.[34]

In view of the information recorded in Volume 1 about the relatively non-dusty character of shale mines and the prevalence of fumes from shot firing, it is not possible to be dogmatic as to whether this syndrome in miners was related more to fumes than to dust or vice versa. Similarly, the retort workers, except those few employed exclusively on tips, will also have been exposed to both fume and dust. It may be that oxides of nitrogen were released underground by shot firing and that these played a significant part in contributing to the functional impairment of men with pneumoconiosis. There has been much debate recently about toxic effects of low levels of oxides of nitrogen; although recent studies of coalminers in Britain and the United States appear to have shown no greatly increased risk of lung disease,[35,36] nevertheless the higher levels likely to have occurred in shale mines may well have had harmful effects at bronchiolar or alveolar level.

As in the radiological study, so in the lung function study it has proved possible to separate out the effects of occupational disease from the effects of age and cigarette smoking. While for some measurements of lung function, case-control differences were greater and age-related loss differed when smoking status was allowed for, there is no evidence that smoking or age by themselves were responsible for the differences observed overall. These must be

attributed either to the presence of pneumoconiosis or to the dust exposure that caused it.

5.7 Relevance of results to United States shale oil industry

Two broad conclusions may be drawn from this study of surviving ex-shale workers. First, the risk of skin disease and skin cancer does not seem to have been appreciably increased, even amongst those workers likely to have had the heaviest exposure to oil and dust. Second, pneumoconiosis occurred in a relatively small proportion of miners and retort workers and this was associated with functional impairment suggestive of some pulmonary fibrosis and associated emphysema.

The absence of serious skin disease is a reassuring finding. This does not however imply that the industry was free of risk; indeed the risk was so well known that energetic steps appear to have been taken to control it and, at least as far as is apparent from this study, these seem to have been effective. It has not been possible so far to investigate these preventive measures in detail, but they included the provision of workplace washing facilities, protective clothing, education of the workforce in personal hygiene and regular medical supervision for the detection of early skin disease. From the point of view of the emergent United States industry, it would seem reasonable to suppose that similar attention to the established principles of preventive medicine and occupational hygiene would be equally effective in preventing hazard to the skin.

The hazard of pneumoconiosis was predictable in the United States industry even before this study took place. By analogy with coalmining, and the analogy is probably quite close in view of the similar mineralogical composition of shale dust and some coalmine dusts, the risk would increase

with increasing dust exposure and would vary with different dust compositions.[37] In Volume 1 we have commented on the similarities and the differences between some US and Scottish oil shales. In general, it may be assumed that if the quartz level of the dust rises above about 10 - 15 per cent, a risk of silicosis becomes evident[38] and dust control measures appropriate to quartz should be applied. For lower levels of quartz, the standard applied in the coalmining industry would probably be appropriate, based as it is on previous careful epidemiological work by the IOM.[39] However, the lack of possibly protective minerals in US shale should be borne in mind. The present studies, because of the lack of any dust measurements in the shale industry, have not been able to provide any clearer guidance. Whatever standard is applied, appropriate methods of worker surveillance should be instituted, including all dust-exposed men. In the peculiar conditions of the Rocky Mountains, where certain processes such as crushing may take place underground and where retorting may be carried out in very confined spaces, it is important to remember that not only miners will be exposed to dust. In the British coal industry, a chest radiograph taken every four years is considered appropriate for worker surveillance. If the United States decides on a similar approach, using the Federal coalmine dust standard, a similar monitoring strategy would seem to be appropriate.

In this volume we have not considered risks of internal carcinomas or other fatal diseases. These matters are discussed in the final volume.

CHAPTER 6

SUMMARY

In order to investigate the prevalence of skin disease and of pneumoconiosis in Scottish ex-oil shale workers, a cross-sectional epidemiological survey has been carried out based on a population enrolled in the 1950 Scottish Oils Ltd Provident Fund. Investigation of the Fund indicated that it would have included almost all industrial workers employed in the oil shale industry between 1950 and its closure in 1962.

The records of the Fund allowed identification of employees and gave a detailed occupational history of each worker from his time of joining the oil shale industry until enrolment. Further information on occupations in the industry was obtained at interview with some workers and with others knowledgable about the industry. A total of 6 359 Provident Fund Forms was found, each relating to a separate individual. Of these, 2 618 men were found to have died and are the subjects of the concurrent mortality study reported in Volume 3. Sixteen men were untraced and 159 found to have emigrated. Invitations to take part in the studies were sent to the remaining 3 566 men.

Of the 3 566 men invited, 1 664 (47%) took part. Comparisons between these men and those who did not take part showed a similar age distribution and history of occupational exposures. Nevertheless, it is likely that the non-participants were in general somewhat more ill than those who did attend, and this should be born in mind in interpreting the results.

The prevalence of a history of skin disease was assessed in the shale miners and oil-exposed workers and compared with that in control groups of non-dust or oil-exposed shale workers and of coalminers. No evidence of an increased prevalence of skin cancer or other skin disease was found in the shale miners or oil workers, even in those

judged likely to have been most heavily exposed. An excess of warts and itching conditions was found among the coalminers.

A survey of smoking habits of the ex-shale workers revealed that 77% had at some time been smokers and almost 50% were current smokers. These percentages were somewhat lower than those of a comparable group of coalminers, though different methods of obtaining the information may have been responsible for these differences. This information on smoking habits was used in interpretation of the radiographic and lung function findings.

The chest radiographs of 1 231 men were each read by ten readers, four of whom were medically qualified and all of whom were experienced in the use of the ILO (1980) classification. Large inter-reader variations were noted but in general an increase in the prevalence of both Category 1/0+ and 2/1+ simple pneumoconiosis with increasing likelihood of exposure to shale dust was found. High categories (above 2/2) were uncommon. Multiple regression analysis of the medical readers' results showed that two had detected relationships between prevalence of radiological change and dust exposure, age and cigarette smoking, one between radiological change, age and dust exposure and the fourth between radiological change and age alone. It is apparent that age and smoking habit as well as dust exposure may influence the chest radiograph and cause uncertainty in the clinical diagnosis of pneumoconiosis.

In all, 74 films were said by one or more readers to show large opacities. Many of these were found on review to be radiographic lesions other than PMF, recorded by one or more non-medical readers. On examination of occupational histories and, in selected cases, general practitioners' records, six films were thought to have radiological appearances consistent with PMF, a prevalence of just under 1% of men exposed to dust in mines and at retorts. In two of these six cases, coalmine dust exposure was probably an important factor.

A group of 61 men, in whom five or more readers had agreed that pneumoconiosis Category 1/1 or greater was present, was selected as cases for comparison with controls in whom at least eight readers had agreed the film to show Category 0/1 or less or ten readers had read 1/0 or less. Measurements of ventilatory capacity, lung volumes and transfer factor were made. Significant reductions in FEV_1, FVC and transfer factor were found in cases, though residual volume and total lung capacity did not differ between the two groups. These differences were not explicable in terms of smoking habits, height or age differences or history of bronchitic symptoms. It is suggested that they may be an effect of pneumoconiosis, or possibly an independent effect of dust and fume exposure.

It is concluded that workers in the Scottish shale oil industry in its latter years were not at excess risk of skin disease, perhaps because of steps taken within the industry to reduce the known hazards of dermatitis and skin cancer. However, pneumoconiosis was a definite hazard of miners and retort workers and its presence was associated with an impairment of lung function suggestive of fibrosis and possibly emphysema as well. It is suggested that prevention of this hazard might sensibly be based on the strategy used in the coalmining industry and, in the absence of further information on dust and fume exposures of shale workers, standards as applied in coalmining should be appropriate. Radiological surveillance of dust-exposed workers, whether in mines or at retorts or tips, is recommended.

REFERENCES

1. WEAVER NK, GIBSON RL. The US oil shale industry : a health perspective. American Industrial Hygiene Association Journal 1979; 40: 460-467

2. COSTELLO J. Morbidity and mortality study of shale oil workers in the United States. Environmental Health Perspectives 1979; 30: 205-208

3. BELL J. Paraffin epithelioma of the scrotum. Edinburgh Medical Journal 1876; 22: 35.

4. SOUTHAM AH, WILSON SR. Cancer of the scrotum : the aetiology, clinical features and treatment of the disease. British Medical Journal 1922; 1: 971-973.

5. POTT P. Chirurgical observations relative to the Cataract, the Polypus of the Nose, the Cancer of the Scrotum, the different kinds of Ruptures and the Mortification of the Toes and Feet. London, 1775.

6. SCOTT A. On the occupational cancer of the paraffin and oil workers of the Scottish shale oil industry. British Medical Journal 1922; 2: 1108 - 1109.

7. LODGE Sir R. (Arbiter) (1917). Report of proceedings before Arbiter on 19th Feb 1917 in arbitration between the Scottish Mineral Oil Association and the Scottish Oil Workers' Association in regard to Sunday labour.

8. SEATON A, LAMB D, RHIND BROWN W, SCLARE G, MIDDLETON WG. Pneumoconiosis of shale miners. Thorax 1981; 36: 412-418.

9. SOUTAR CA, COPLAND LH, THORNLEY PE, HURLEY JF, OTTERY J, ADAMS WGF, BENNETT B. Epidemiological study of respiratory disease in workers exposed to polyvinylchloride dust. Thorax 1980; 35: 644 - 652.

10. MEDICAL RESEARCH COUNCIL. Report of the working party on research into chronic bronchitis. London: Medical Research Council, 1976.

11. Guidelines for the use of the ILO International Classification of radiographs of pneumoconioses. Geneva: International Labour Office 1980. (Occupational Safety and Health Series No. 22 (Rev.))

12. COPLAND L, BURNS J, JACOBSEN M. Classification of chest radiographs for epidemiological purposes by people not experienced in the radiology of pneumoconiosis. British Journal of Industrial Medicine 1981; 38: 254-261.

13. QUANJER PH, ed. Standardised Lung Function Testing. Luxembourg : Commission of the European Communities, 1983. (Bulletin Europeen de Physiopathologie Respiratoire 1983; 19: suppl. 5).

14. COTES JE. Lung Function. Oxford: Blackwell, 1979.

15. AGRICOLA G. De re metallica, 1556. Hoover HC and Hoover LH, translators. London: The Mining Magazine, 1912.

16. REHN L. Blasengeschwulste bei Fuchsin-Arbeitern. Archiv fur klinische Chirurgie 1895; 50: 588-600.

17. HARTING FH, HESSE W. Der Lungenkrebs, die Bergkrankheit in den Schneeberger Gruben. Vierteljahrsschrift fur gerichtliche Medizin 1879; 31: 102-132.

18. SCOTT A. The occupational dermatoses of the paraffin workers of the Scottish shale oil industry, with a description of the system adopted and the results obtained at the periodic examination of these workmen. 8th scientific report, Imperial Cancer Research Fund, 1923.

19. WILLIAMSON DM, VICKERS HR. Occupational dermatitis in miners. In: Rogan JM, ed. Medicine in the Mining Industries. Heinemann: Oxford, 1972: 177-198.

20. JACOBSEN M, MILLER BG, MURDOCH RM. Experience with the ILO (1980) Classification in an epidemiological study of asbestos workers' chest radiographs. In: Bergbau-Berufsgenossenschaft. VIth International Pneumoconiosis Conference 1983, Bochum. Geneva: International Labour Organisation, 1984: 868-880.

21. SOUTAR CA, COPLAND LH. THORNLEY PE, HURLEY JF, OTTERY J, ADAMS WGF, BENNETT B. Epidemiological study of respiratory disease in workers exposed to polyvinylchloride dust. Thorax 1980; 35: 644-652.

22. DICK JA, JACOBSEN M, GAULD S, PERN PO. The significance of irregular opacities on the chest radiographs of British coal miners. In: Bergbau Berufsgenossenschaft. Proceedings of the VIth International Pneumoconiosis Conference 1983, Bochum. Geneva : International Labour Office, 1984: 283-299.

23. MORGAN WKC, SEATON A. Occupational Lung Diseases, 2nd ed. Philadelphia: WB Saunders 1984: Chapter 11.

24. MORGAN WKC. Prevalence of coalworker's pneumoconiosis. American Review of Respiratory Disease 1968; 98: 306-310.

25. BENNETT JG, DICK JA, KAPLAN S. The relationship between coal rank and prevalence of pneumoconiosis. British Journal of Industrial Medicine 1979; 36: 206-210.

26. LE BOUFFANT L, DANIEL H, MARTIN JC, BRUYERE S. Effect of impurities and associated minerals on quartz toxicity. In: Walton WH, ed. Inhaled Particles V. Oxford : Pergamon Press, 1982. (Annals of Occupational Hygiene 1982; 26: 623-634).

27. SEATON A, LAPP NL, MORGAN WKC. Lung mechanics and frequency dependence of compliance in coal miners. Journal of Clinical Investigation 1972; 51: 1203-1211.

28. MORGAN WKC, BURGESS DB, LAPP NL, SEATON A. Hyperinflation of the lungs in coal miners. Thorax 1971; 26: 585-590.

29. COTES JE, FIELD GB. Lung gas exchange in simple coalworkers' pneumoconiosis. British Journal of Industrial Medicine 1972; 29: 268-273.

30. COCKCROFT A, LYONS JP, ANDERSSON N, SAUNDERS MJ. Prevalence and relation to underground exposure of radiological irregular opacities in South Wales coalworkers with pneumoconiosis. British Journal of Industrial Medicine 1983; 40: 169-172.

31. COCKCROFT AE, WAGNER JC, SEAL RME, LYONS JP, CAMPBELL MJ. Irregular opacities in coalworkers' pneumoconiosis - correlation with pulmonary function and pathology. In: Walton WH, ed. Inhaled Particles V. Oxford: Pergamon Press, 1982. (Annals of Occupational Hygiene 1982; 26: 767-787).

32. RUCKLEY VA, GAULD SJ, CHAPMAN JS, DAVIS JMG, DOUGLAS AN, FERNIE JM, JACOBSEN M, LAMB D. Emphysema and dust exposure in a group of coalworkers. American Review of Respiratory Disease 1984; 129: 528-532.

33. MUSK AW, COTES JE, BEVAN C, CAMPBELL MJ. Relation between types of simple coalworkers' pneumoconiosis and lung function. A nine year follow-up study of subjects with small rounded opacities. British Journal of Industrial Medicine 1981; 38: 313-320.

34. KING VA. Morphological investigations of fibrogenic action of Estonian oil shale dust. Environmental Health Perspectives 1979; 30: 153-156.

35. ROBERTSON A, DODGSON J, COLLINGS P, SEATON A. Exposure to oxides of nitrogen : respiratory symptoms and lung function in British coalminers. British Journal of Industrial Medicine 1984; 41: 214-219.

36. REGER R, HANCOCK J, HANKINSON J, HEARL F, MERCHANT J. Coal miners exposed to diesel exhaust emissions. In: Walton WH, ed. Inhaled Particles V. Oxford: Pergamon Press, 1982. (Annals of Occupational Hygiene 1982; 26: 799-815).

37. HURLEY JF, BURNS J, COPLAND L, DODGSON J, JACOBSEN M. Coalworkers' simple pneumoconiosis and exposure to dust at 10 British coalmines. British Journal of Industrial Medicine 1982; 39: 120-127.

38. SEATON A, DICK JA, DODGSON J, JACOBSEN M. Quartz and pneumoconiosis in coalminers. Lancet 1981; ii: 1272-1275.

39. JACOBSEN M, RAE S, WALTON WH, ROGAN JM. New dust standards for British coal mines. Nature 1970; 227: 445-447.

Appendix 1

The "1950 Provident Fund of Scottish Oils Ltd."

In this appendix the Provident Fund (Fund) is discussed under a) the historical background to the Fund, b) criteria for membership of the Fund, and c) administration of the Fund.

(a) Historical Background

By 1905 only six companies controlled the Shale Industry in West Lothian: The Broxburn Oil Co. Ltd., The Dalmeny Oil Co. Ltd., The Oakbank Oil Co. Ltd., The Pumpherston Oil Co., Ltd., James Ross & Co. Ltd., and Young's Paraffin Light & Mineral Oil Co. Ltd. In 1919 the ordinary shares of these six companies were acquired by a new company, Scottish Oils Ltd. (SOL), whose ordinary capital in turn was subscribed by the Anglo-Persian Oil Co. Ltd., later the Anglo-Iranian Oil Co. Ltd., now the British Petroleum Co. Ltd.[1]. SOL also acquired the properties and goodwill in Scotland of the British Petroleum Co. Ltd., and the Homelight Oil Co. Ltd., both of which were engaged in the distribution of imported oil products.[2]

In a general circular of the Anglo-Iranian Oil Co. Ltd. (probably drafted early in 1948)[3], it was announced that the Directors had decided to make provision of retirement benefits to those employees not covered by the existing Pension Scheme. It was decided that the payment of a Lump Sum Provident Fund payment upon retirement would be favoured by most employees, since pensions were provided by the State. In addition, a SOL Service Pension Scheme was already available to employees with 25 consecutive years service when they reached 65, or 45 years service at any time.[3]

The Fund was non-contributary on the part of the employees. Therefore, it can be assumed that almost all shale workers who qualified would have sought membership.

Informed sources have confirmed that SOL was the only Company involved in oil shale work in West Lothian after 1919.

The first P-forms that were issued are dated Dec. 1950; after the general shut-down of the Industry in 1962, applications for membership of the Fund by workers at BP Grangemouth continued to be made until September 1971 when the Fund was closed to new applicants; at this time a New Pension Fund for Industrial Staff took its place.

(b) Criteria for Membership to the Fund

The Fund commenced on 1st January 1948 and members were admitted subject to the following rules: Applicants should (i) be in continuous service with the Company for at least two years, (ii) not be eligible for any other superannuation benefit.[4] In January 1966 the requirement under (i) above was reduced to six months.[5]

"Staff members" (clerical workers, works foremen and managerial staff) were excluded from the Fund under clause (i) above, since they already were eligible for a Pension Fund. When workers were promoted to Staff level, they remained eligible for the amount payable to them at the time of promotion. The P-forms of such promoted workers were retained by the office administering the Fund.

(c) Administration of the Fund

(i) Notification of eligibility

It was customary for a worker to be informed by the Administrative Office at his plant when he became eligible to apply for membership to the Fund.

(ii) Information on Forms

Application was made by completing a P-form. The applicants usually completed these forms themselves, but at some plants they were completed by clerks and signed by the applicant. The dates of the stated occupational history were then checked against existing records; the main record that was used for corroboration was the "Register of Employees" held by each plant. The occupational history referred to all occupations held in SOL prior to the application date.

(iii) "Leaver"-forms

When a man left SOL, his last occupation in SOL, together with the date of and reason for leaving were recorded on a "Leaver"-form, which was then attached to his P-form and filed. "Leaver"-forms also included the worker's date of birth and address at the time of leaving.

If a man died while in service with SOL, this fact was recorded on the "Leaver"-form with the date of death. If a man retired from SOL due to ill health, this fact was recorded on the "Leaver"-form.

(iv) Deaths after leaving SOL

When men died after leaving SOL, this fact was not recorded on the forms but in a ledger entitled "Allowances to Retired Employees"

(v) Ex Gratia Payments

Although the Provident fund originally made provision for a lump sum payment only, in 1979 BP (London) decided to add an ex gratia allowance, which led to a review of the Provident Fund membership list and tracing of beneficiaries.

The *ex gratia* allowance is payable to workers or their wives who had more than 10 years continuous service in SOL and are 60 years and older. This allowance was still being paid monthly (at the time of writing) to workers who qualified and for this reason the "Allowance to Retired Employees" -ledger was being kept up to date. In 1981 the management of BP (London) extended the *ex gratia* payments to include men over 55 years or who retired prematurely on medical grounds or died after more than 5 years service. Tracing of potential beneficiaries was undertaken and these addresses were made available to the IOM.

(vi) Notification of Deaths

The Fund administrators were usually informed of the death of the beneficiary, since payments were made by cheques made out in the name of the beneficiary.

(vii) Fund administrators

The Fund was initially administered from the SOL offices in Glasgow, by Messrs Brodie and N. Gibson. The latter was in charge of the Fund for 17 years until 1966, when the SOL offices were moved to the BP Refinery at Grangemouth. In 1967 Mr G Webster took over the administration until December 1982, when he retired. Ledgers containing details of payments to men were subject to external audit. At the time of writing the fund was being administered by Miss J Stuart at BP Grangemouth.

REFERENCES

1. Fraser Cook: The Scotish Shale Oil Industry. In: Oil Shale - the environmental challenges: Procedings of an International Symposium, August 11-14, 1980, Vail, Colorado. Ed.Kathy Kellog Patersen. Colorado School of Mines Press, Golden, Colorado, 1981.

2. "Lest we forget" - the story of the decline and ? of the Scotish Shale Industry, by Walter Nellies, General Secretary N.U.S.M. O.W. Name of publisher and date of publication not available. (A booklet giving an account of the economic pressures on and industrial relations within the Shale Industry. Probably published late 1945 or early 1946).

3. Draft General Circular: Anglo-Iranian Oil Company Ltd. "1948" Provident Fund Scheme. Undated. (A circular in which the proposed Provident Fund is described).

4. Rules of the "1950" Provident Fund of the British Petroleum Company Limited and its associated companies - embodying all amendments and additions up to 2nd December, 1955. (A legal document).

5. "1950" Provident Fund Scheme of the British Petroleum Company Ltd., and its associated companies. Issued October, 1968. (An explanatory circular incorporating the amendments to the Rules made in January, 1966).

A7

Appendix 2

No.		

SCOTTISH OILS, LIMITED

AND ASSOCIATED COMPANIES

"1950" PROVIDENT FUND SCHEME

Form of Application for Membership

Surname (IN BLOCK CAPITALS) ....

Christian Name(s) (*in full*) (STATE MR., MRS OR MISS) ....

Present Occupation ....

Presently employed at .... { Works / Mine / Pit

Check No. (*if any*) ....

Date of Birth ....

Date of Death

Place of Death

Address

Date left Industry

Last Occupation

EMPLOYED AT (State at which Works or Mine)	EMPLOYED AS (State designation or type of work)	DATE		FOR OFFICE USE ONLY
		FROM	TO	

I declare that to the best of my knowledge the above information is correct. I hereby apply for admission to Membership of the "1950" Provident Fund. I agree to be bound by the Rules of the Scheme, which are summarized in the explanatory circular dated Jan. 1966 which I have received.

Date..19 . *Signature* ....

(When completed, to be returned to Cashier at present place of employment.)

Appendix 3

Procedures adopted to trace men whose vital status remained uncertain after DHSS enquiry.

Following the search procedures outlined under 3.2.1 (Fund Administrative Records), 3.2.2 (Local Enquiry) and 3.2.3 (DHSS) the vital status of 1612 remained uncertain. Many (473) of these men were stated to be alive by DHSS (who forwarded letters to them) but they failed to reply to the invitation to participate in the study. We therefore lacked direct evidence of their survival. The remainder fell into one of the five categories of men whom DHSS could not trace (listed in Section 3.2.3).

The following procedures were adopted to obtain the vital status for the 1612 men whom DHSS could not trace with certainty.

1. Intensive local searches

A feasibility study was done to determine whether the DHSS category "Unable to Identify", could be traced by intensive searches within the communities in the vicinity of Edinburgh. Ninety men were selected out of the 176 thus designated and the IOM's clerks were asked to visit the last known address (obtained from the Fund Administrative Office). Eighty three addresses were visited and the following results were recorded using an especially designed proforma:

	No.	(%)
No trace:		
House demolished	23	(28)
Unknown to present occupants	29	(35)
Traced:		
alive	15	(18)
deceased	16	(19)
	83	
NOT VISITED	7	

Of the 15 men that were contacted, 9 agreed to participate in the project; 8 would answer questionnaires and 1 would have an X-ray as well. The relatives of 6 deceased men were found at the address and an additional 10 were said, by neighbours, to have died. The study proved that an intensive search of this kind could yield results that were unobtainable from DHSS. It proved to be very expensive, requiring 60 man-hours to trace the above mentioned 31 men.

2. Cumulative Death Index

The compilation of a death index was commenced in 1974 by the Scottish Registrar General. It is updated every three months and is maintained on microfiche. Since it is arranged in alphabetical order of deceased persons' surnames, it provided a readily accessible means of finding the dates of death of some men (who died in Scotland after 1973). The names on the list of 1612 "untraced" names (including men who might have emigrated) remaining after the searches by the DHSS were compared, individually, with those on the cumulative death index. In this manner the dates of death (and the reference numbers of their death certificates) of 47 men were obtained.

3. The National Health Service Central Registers (NHSCR)

The NHSCR provide another invaluable method for the tracing of individuals. Unlike the DHSS, no Letter Forwarding Service exists, but the offices are willing to provide approved investigators with information regarding vital status of individuals. The NHSCR is responsible for monitoring the movements of patients from one general practitioner's practice to another. These records are used to verify general practitioners' list claims. The Scottish records are kept at Ladywell House in Edinburgh, under the control of the General Register Office (Scotland). The records for England and Wales are kept at Southport, under the control of the Office of Population Censuses

and Surveys (OPCS). Although no addresses can be obtained from the NHSCR records, the finding of an individual's name is good evidence that he/she is alive and registered with a general practitioner. Using these records the records of 1612 men were looked for, and 1363 were found to be alive in the UK, 65 were found to have died before 1.1.83, 136 emigrated and 48 could not be located. Where indicated the NHSCR (OPCS) office at Southport was consulted.

Appendix 4

STUDY: EVALUATION OF P-FORM OCCUPATIONAL HISTORY AGAINST THE LEDGER ENTITLED "ALLOWANCES TO RETIRED EMPLOYEES".

AIM: To determine the prevalence and qualitative nature of differences in the occupational histories as recorded on the P-forms and in the Ledger.

The full occupational histories as well as "last occupation" as recorded on the Provident Application forms were compared with those recorded in the Ledger entitled "Allowances to Retired Employees". This Ledger is described in detail, in order to demonstrate that it is, in itself, a valid source of information for this comparison.

The Ledger entitled "Allowances to Retired Employees"

This is, essentially, a list of the names of retired personnel, in which was recorded their work history with Scottish Oil Ltd (SOL) or its precursors. The purpose of the Ledger was to keep a record of employees who qualified for an *ex gratia* payment to them (or their widows) on a monthly basis, after retiring.

Each individual's occupational history was recorded in the Ledger in order to determine whether he qualified for such *ex gratia* payments. On most pages, there were columns recording the following: "Last place of employment", "last job", "total years of service with SOL" followed by previous places of employment with dates. The qualifying criteria for payment were (i) a total of > 40 years service with SOL or (ii) redundancy after the age of 55 years with > 20 years service. The names of all men who met these criteria were entered in the Ledger. Men who were "borderline" could apply to the Trustees for special consideration. The *ex gratia* payments started in the 1930's and are still in effect today. Men who died whilst being in the employment of SOL did not qualify for the *ex gratia* payments, and their names were not entered in the ledger. Similarly, if men left SOL to seek employment elsewhere, or were dishonourably discharged, or were too young when they retired, their names were not entered in the Ledger.

If a man left the company and returned later, the reason for the break in service was recorded. (In instances where breaks in service were not attributable to SOL the individual concerned would be penalised).

The recorded occupational history was based on specific "Ex Gratia Application Form", completed by men when they retired. This information was, evidently, checked against company employee records. The fact that dates were recorded specifying day and month as well as years would suggest that these were in fact copied from written records, rather than relying on men's memories. The Register of Employees might possibly have been the parent source of information. Such registers were maintained at each pay-point in the company.

The Ledger consists of three volumes, each sub-divided into the administrative precursors to the current Pensions Office at BP Refinery, Grangemouth. The lay-out is as follows:

Volume One	Pages	First date	Last date
Pumpherston Oil Co	59 - 119	18.10.1943	2.02.1969
Young's Paraffin Light & mineral Oil Co. Ltd.	69 - 192	9.12.1940	23.04.1962
Volume Two			
Broxburn Oil Co. Ltd	49 - 103	3.10.1938	24.11.1958
Oakbank Oil Co. Ltd	27 - 119	23.01.1939	15.12.1958
Grangemouth Petroleum Ref. Ltd	1 - 12	18.03.1938	23.04.1962
Scottish Oils Ltd	5 - 15	3.03.1947	29.01.1962
Volume Three			
Youngs Paraffin Light & minerals Co. Ltd	1 - 84	7.05.1962	1.12.1975*
Scottish Oils Ltd (Redundancy)	1 - 8	30.04.1962	3.09.1973*
BP Refinery Ltd	1 - 19	10.09.1962	19.01.1976*

* No occupational history was recorded after 1966.

The missing pages could not be accounted for by the present fund administrators. They probably contained information relating to deceased men whose widows had died, thereby leading to termination of ex gratia payments to their estates. Occupational histories were not recorded after 1966, since the ex gratia fund administration was

transferred from Glasgow to BP Refinery, Grangemouth in that year. Since the P-forms were kept in the latter office, the need for a duplicate set of occupational histories no longer existed. The Ledger entries were made in chronological order, according to the dates of retirement. The Provident Fund number was not recorded in the Ledger, since the Provident Fund as such had nothing to do with the *ex gratia* payments.

The Ledger is still in daily use as a reference book which contains the names of ex-workers or their widows receiving monthly *ex gratia* payments. In the event of a man's death the date is recorded against the deceased's name. Relatives usually promptly inform the Administrators of a man's death, since the *ex gratia* payments are made by cheque, payable in his name only.

PROCEDURE

Outline

A sample of P-forms was selected. Their names were found in the Ledger and their identity confirmed. Using a *pro forma*, discrepancies in the occupational histories recorded on the forms and in the Ledger were annotated. These discrepancies were tabulated.

Sample

The P-forms of men who were known to have died by 4.3.1983 were arranged in alphabetical order according to surnames. Starting from"A", every tenth form was extracted. With respect to both the order in which the forms were originally completed and the order of entry into the ledgers, this selection procedure extracted a random sample.

Identity

Using the "Date Left Industry" as recorded on the P-form as a guideline, the pages of the appropriate volume were scrutinized. In most instances the man's name was quickly located by this method. The

man's identity was confirmed by comparing his full name, date of birth and last address with those on the form. The names of some men could not be found in the appropriate chronological slot and a page-by-page individual search through the ledger was conducted, after which several names remained untraced.

Recording of discrepancies

Any discrepancies in the occupational history recorded "on the P-form and not in the Ledger" or "in the Ledger and not on the P-form" were recorded in the appropriate columns on the pro forma used for the study.

RESULTS

The selected sample comprised 161 Provident Fund Forms. Of these 41 had died whilst employed by Scottish Oils Ltd.; thus their names were, by convention, not entered in the Ledger. The names of seven men could not be found in the Ledger; two retired in the 1970's and the other five all retired between 1956 and 1958 (inclusive). This left 113 whose entries could be located in the Ledger. Of these, three were entered after 1966, when occupational histories ceased to be recorded in the Ledger. (Table 1).

Systematic differences

All the P-forms contained details of titles of jobs held at various sites of employment including the last job held before retirement. The Ledger did, however, contain full details of sites of employment, breaks in service and dates. In general, the P-forms recorded dates of breaks in service with the Industry but did not cite the reason for such a break (e.g. illness or temporary closure of a shale mine), except when the break was due to service in the Forces during World War II. In 5 instances (Nos 7, 8, 10, 12, 16) breaks were ascribed to "illness" in the Ledger. It should be noted that a major systematic deficiency of the job histories on the P-forms is that no updates were made of job movements from the date of application until retirement.

The present analysis indicates that if the assumption were made that the job that was held at the time of completing the form was kept until retirement, the assumption would be erroneous in 3/110 (2.7%) of cases (Nos 1, 5 & 10).

Specific differences

In addition to the systematic differences outlined above, the recorded work histories in the Ledger as against the Forms differed in 38 instances with regard to sites of work, periods of unemployment and dates of employment. Table 2 summarises the findings.

Since the primary aim of the study was to assess the prevalence and implications of deficiencies in the occupational histories recorded on the P-forms further analysis will be confined to this group (n = 21).

At the time of analysis it was found that the work histories of one man (No.H27) differed totally in the two records (Forms VS Ledger). It would appear that his identity was mistaken for another man's. Table 3 details the nature of the discrepancies in recorded work histories. It will be seen that in 9 instances, adding the additional information to the P-forms led to no change to the man's allocation in the dust and oil categorization system.

DISCUSSION

Using the Ledger as a separate source of information, the information on the Provident Fund Application forms could be assessed in 110 out of 161 selected forms.

The forms were found to have the following deficiencies:

1. Absence of job records during the period between completing the form and cessation of dust/oil exposure (either retirement before or during 1962 when the industry closed). This study indicated that if the job that was held at the time of completing the form were assumed to have been held until retirement, the assumption would be wrong in about 3% of cases. (However, the assumption

would probably tend to err on the side of an overestimation of dust/oil exposure, since men tended to move from "dirtier" and more physically demanding to "cleaner" jobs. Also, the assumption clearly affected a small fraction of a man's total work experience).

2. Breaks in service recorded on the P-forms were most often due to illness, rather than periods of work in other (dusty) occupations. The assumption that all breaks for unspecified reasons involved "time outwith the Industry and not in other dusty jobs" can thus reasonably be made.

3. In 2.77% of cases (i.e. three men) the occupational histories on the forms did not record short periods of employment in the Industry, leading to a minor underestimate of the total work experience.

CONCLUSION

A comparison of the occupational histories recorded on the P-forms against another well-documented source (the Ledger) showed that, although discrepancies existed, they were not of major significance. The usage of the P-forms as the data base would tend to lead to an overestimate of dust/oil exposure in a small proportion of cases. In a smaller proportion of cases it would lead to an underestimate of dust/oil exposure.

TABLE 1

Number of P-forms extracted for study	161		
Men died whilst employed with Scottish Oils .. .. (not in Ledger)		41	
Names could not be found in Ledger		7	
Names located in Ledger		113	
Occupational histories recorded in Ledger			110*
	161	161	

* Study group

TABLE 2

No difference between Ledger and P-form	75	68.2%
P-form contained details not recorded in Ledger ..	14	12.7%
Wrong identity	1	
Ledger contained details not recorded on P-form	20	19.0%

TABLE 3: INFORMATION IN LEDGERS, NOT ON FORMS

	Prov. No.	Recorded in Ledger as:	Recorded on Form as:	Effect on Category*
1.	R209:11	No.6 Mine Hopetoun 1906-1907	Glendevon Mine 1906-1907	0
		Roman Camp Mine 1937-4.3.52 Youngs Co Hopetoun Works 5.3.52-24.10.53 Youngs Co Hayscraigs A&B 26.1.53-27.11.55 Broxburn Co Hayscraigs A&B 28.11.55-23.12.55	Roman Camp No.6 1937-23.12.55 Date of form: 8.1.1951	Failed to record 3 yrs spent at works
2.	W78:11	Duddingston No.3 5.7.20-30.8.54 Philipstoun No.1 31.8.54-17.6.61	Duddingston No.3 5.7.20-17.6.61	0
3.	P158:11	Niddry Castle Works 18.8.58-18.2.61	(Implied) Roman Camp Works: 11.8.46-18.2.61	0
4.	P158	Champfleurie Oil Co. 1900-1902	First entry in Dec. 1902	2 yrs more in shale industry
5.	R280:11	Name recorded as "Chambers" Hopetoun Works 2.5.21-8.9.22	Name = Chalmers = Break in service 1921-1927	2 more years in works
		Youngs O. Co "Roman Camp Works" BP Refinery Grangemouth 4 years	Youngs Oil Company Not recorded separately	0 4 years in no exposure group
6.	A318	Addiewell Works 2.9.47-4.8.56	Addiewell Works 2.9.47 to date of form 15.1.51	0
		Westwood Works 6.8.56 to date (11.5.62)		0
7.	R276	"Off work since 26.11.51, operation on eyes" - entry of date of leaving 7.3.52	No record of this	4 less months in works
8.	B75:11	"Break = Oct. 1931 for 6 months due to illness	No. 5 Mine Deans 1928-1932 Roman Camp Mines 11.4.32-22.9.35	6 months less in mines
9.	B247:11	No. 35 Pit 2.4.14-10.12.1918 Curldubs mine (Broxb.) Dec. 1918-1921	No. 35 Pit 2.4.14-1921	0
10.	W291:11	No. 3 Mine: 1911-8.4.56 Niddry Castle Works: 9.4.56-9.2.58 Philipstoun No. 1 Mine: 10.2.58-8.12.58 Off work since 7.11.58 - Medical Cert.	No. 3 Mine Duddingston May 1911 and by implication to 10.12.58 Date on form: 7.1.51	worked at oil works for 2 years
11.	W286	Philipstoun No. 6 Mine 3.12.56-9.3.57 Retiral	Duddingston No. 3 1906 - implied until 9.3.57 Date of form 15.1.51	0
12.	P350:11	Pumpherston No. 4 Mine 1922-1925 Off work: accident 1925-1928	Pumpherston No. 4 Mine 1921-1928 Pumpherston Ref 4.1.29 and implied up to 13.3.59 Date of form 19.12.1950	3 years less on mine
13.	W253:11	Recommended work after illness on 26.7.1920	Recommended work on 26.3.1920	4 months less on mine
14.	W333	Baads Mine 1916-1926	No record of this. Record starts in June 1938	Coal work x 10 years
15.	P864	"Outwith Industry Aug 56 - Dec 1964	Pumpherston Works 22.7.57-31.12.64 implied. Date of form 6.8.1959	8 years less at works
16.	M46	Uphall Works 1917-1921 Break 1921-July 1922	First entry: Blacksmith at Middleton Hall 1922	4 more years in works
17.	G211	Last job at BP Refinery = rigger and rope splicer	Grangemouth Refinery = labourer	0
18.	A41	Pumpherston Works 17.9.56-16.10.64	Implies: Addiewell Works fitter 6.10.13-16.10.64 Date of form 22.12.1950	0
19.	W63	Duddingston Mine and Newcastle Works Dec 1932-17.5.61	Implies: Duddingston Mine May 1930 to 17.5.61 Date of form 16.1.1951	unknown period at works
20.	P442	Job name recorded "Fitter labourer"	No record of job name	makes categorisation possible

*Effect that incorporation of ledger information would have on the category of dust and oil exposure

Appendix 5

SHALE JOB TITLE CLASSIFICATION CODES

PLACE OF WORK CODES

01 = Mine
02 = Retort
03 = Refinery (except Grangemouth Refinery), Candle factory & Soapworks
04 = Depot, Jetty, Pipeline
05 = Brickworks
06 = Middleton Hall
07 = Grangemouth Refinery
08 = Collieries
09 = Breaks in other (non-shale, non-coal) noxious fume/dust work places
10 = Breaks in non-dusty/non-noxious work places
11 = School
12 = Quarry (shale)
14 = Unspecified places of work in the shale industry
15 = Unspecified places of work outwith the shale industry

JOB TITLE CODES

MINES

01 = Faceworkers
02 = Elsewhere, underground
03 = Maintenance
04 = Surface workers,exposed to dust
05 = Other: surface workers not exposed to dust
61 = General worker
62 = Labourer: Labour oncost
63 = Miner
64 = Pumpsman, spare pumpsman, water pumper
65 = Oncost

RETORT WORKS

08 = Retort bottom
09 = Retort top
89 = Retort top and bottom
10 = Crusher/breaker
11 = Maintenance
12 = Process in oil exposure, not dust
13 = Other - no direct exposure to oil or dust
14 = Tipmen and bing workers
15 = Elsewhere in retort works eg. boilerman etc.,
71 = Labourer. Boy labourer, Foreman labourer. General labourer
72 = Cleaner
73 = Oncost, general oncost, oncost worker
74 = General worker. Worker
75 = Shale worker
76= "Trainee"

REFINERY: INCLUDES DETERGENT, SOAP, CANDLE AND WAX FACTORIES

16 = Process workers,including all "labourers","workers","general workers"
17 = Waxworks, candlework
18 = Maintenance workers
19 = Other: jobs not specially related to oil refining process
e.g. power station workers, clerks, drivers, watchmen

BRICKWORKS

24 = Brickworkers with dust exposure
25 = Maintenance
26 = Other: at brickworks, no direct exposure

COALMINING

30 = Face
31 = Preparation
32 = Development
33 = Hard Heading
34 = Elsewhere underground
35 = Dusty on surface
36 = Non-dusty on surface
37 = "Coal miner"

"NOXIOUS" OCCUPATIONS OUTSIDE COALMINING

41 = All mining (except coal mining in UK)
Boiler scaler and stoker
Brass moulder
Brickworks and brickyards
Carbon brush factory
Cement worker
Coal baggers and merchants
Demolition
Furnacemen in Aluminium works
Iron moulder
Loco firemen
Pottery worker
Power station ash wheeler
Steel foundry worker
Stone quarry worker
Tunneler

42 = Acid fumes
Welding
Coke ovens
Gasworks hot metal sheet scaler
Rubber works
TNT

43 = Farming
Flour mills
Poultry worker

44 = Asbestos (heavy exposure)

45 = Asbestos (light exposure)

Appendix 6

EVALUATION OF THE OCCUPATIONAL HISTORY CODE AND DICTIONARY

Aim: To evaluate the completeness of the dictionary and the ease of application of the code.

Sample

It was decided to select the names of men who were likely to have the longest period of employment in the shale industry and therefore likely to have the largest number of job names on their Provident Fund occupational history forms. From the computer data bank, the details of the 20 oldest members (according to date of birth) from each Provident Fund Registration Office were extracted. There were 16 offices (some responsible for fewer than 20 men) and 293 names were thus obtained. The majority of men had died.

Procedure

The Job names on the forms were coded, using the dictionary.

Results

There were no systematic flaws in either the code or dictionary. Twenty-seven unrecorded job names had to be inserted in the dictionary.

Despite its large volume, the dictionary was easy to use and after some practice 20-40 records per hour could be coded.

CONCLUSION

The dictionary in its present form is satisfactory and can be recommended for use in the coding of the study group.

Appendix 7

EXAMPLES OF INVITATIONS, LETTERS, FORMS AND QUESTIONNAIRES

1. First invitation format
2. Reply to queries related to first invitation
3. Second invitation format
4. Reminder invitation
5. Third invitation formats
6. Invitation sent to colliery control population
7. Invitation to colliery control population sent via DHSS
8. Dermatology questionnaire - first format
9. Dermatology questionnaire - second format
10. Smoking questionnaire
11. Invitation to men to participate in PFT survey
12. Respiratory symptoms questionnaire

Telephone 031 667 5131

Our Ref
Your ref

Institute of
Occupational Medicine

Roxburgh Place
Edinburgh EH8 9SU

7.1. First Invitation Format

Dear Mr.

This medical research institute has been asked to study the health of men who worked in the shale and coal industries around Edinburgh.

We should be grateful if you would agree to help us by participating in this research study.

You will be asked to fill in a short form on your health that we will post to you. The information that you supply will be treated confidentially. Later, you may be asked to have a chest X-ray. If required, we will provide assistance with transport to our X-ray unit in your area. We will send you a brief medical report on the X-ray on your request.

I very much hope you will agree to help. Please complete the questions below and return this letter in the stamped addressed envelope provided.

Yours sincerely,

Dr A. Seaton
Director.

P.S. A raffle will be held for all those agreeing to take part and four hampers worth £25 each will be awarded to the winners.

I am prepared to answer a short questionnaire on my health. (YES or NO) ______

I am prepared to attend for an X-ray of my chest. (YES or NO) ______

Name: ....
Address: ....
....
Tel. No.: ....
Date of Birth: ....

Office Use Only	
Number	
S	C

P.S. : <u>PLEASE NOTE</u>: SHALE SURVEY : INSTITUTE OF OCCUPATIONAL MEDICINE

The survey includes all men who were members of the Scottish Oils Limited 1950 Provident Fund. This will include all workers at shale mines, retort works, refineries, acid works, detergent factories, candle factories, shale brick works, oil depots and jetties, and Middleton Hall. We are interested in all the health effects of the industry, including direct or indirect (e.g., watchmen, maintenance men, caretakers, etc.) exposure to dust, fumes, oils and waxes.

Telephone 031 667 5131

Our Ref
Your ref

Institute of
Occupational Medicine

Roxburgh Place
Edinburgh EH8 9SU

7.2. Reply to queries related to First Invitation

Dear Sir,

Thank you for replying to our recent request for your co-operation in our study of workers in the shale industry. I note that you stated that you were unwilling to participate in the study since you had never been a shale miner. However, the survey includes all men in the shale industry who were members of the Scottish Oils Limited 1950 Provident Fund. This will include all workers at shale mines, retort works, refineries, acid works, detergent factories, candle factories, shale brick works, oil depots and jetties and Middleton Hall. We are interested in all the health effects of the industry, including direct or indirect (e.g. watchmen, maintenance men, caretakers etc.) exposure to dust, fumes, oils and waxes.

The study should therefore include workers, like yourself, who were not shale miners. In the light of this, would you be prepared to reconsider your decision not to take part in this survey?

I very much hope you will agree to help. Please complete the questions below and return this letter in the stamped addressed envelope provided.

Yours sincerely,

Dr A. Seaton
Director.

P.S. A raffle will be held for all those agreeing to take part and four hampers worth £25 each will be awarded to the winners.

I am prepared to answer a short questionnaire on my health. (YES or NO) ______

I am prepared to attend for an X-ray of my chest. (YES or NO) ______

Name: ....

Address: ....

....

Tel.No.: ....

Date of Birth: ....

Office Use Only	
Number	
S	C

Telephone 031 667 5131

Our Ref
Your ref

Institute of
Occupational Medicine

Roxburgh Place
Edinburgh EH8 9SU

7.3. Second Invitation format

Dear Mr.

This medical research institute has been asked to study the health of men who worked in the shale, oil and coal industries around Edinburgh.

The survey includes all men who were members of the Scottish Oils Limited 1950 Provident Fund. This will include all workers at shale mines, retort works, refineries, acid works, detergent factories, candle factories, shale brick works, oil depots and jetties, and Middleton Hall. We are interested in all the health effects of the industry, including direct or indirect (e.g. watchmen, painters, maintenance men, caretakers, etc.) exposure to dust, fumes, oils and waxes.

We should be grateful if you would agree to help us by participating in this research study.

You will be asked to fill in a short form on your health that we will post to you. The information that you supply will be treated confidentially. Later, you may be asked to have a chest X-ray. If required, we will provide assistance with transport to our X-ray unit in your area. We will send you a brief medical report on the X-ray on your request.

I very much hope you will agree to help. Please complete the questions below and return this letter in the stamped addressed envelope provided.

Yours sincerely

Dr A.Seaton,
Director.

P.S. A raffle will be held for all those agreeing to take part and four hampers worth £25 each will be awarded tothe winners.

I am prepared to answer a short questionnaire on my health. (YES or NO) ______

I am prepared to attend for an X-ray of my chest. (YES or NO) ______

Name: ....

Address: ....

....

Tel. No: ....

Date of Birth: ....

Office Use Only	
Number	
S	C

Telephone 031 667 5131

Our Ref
Your ref

A30

Institute of
Occupational Medicine

Roxburgh Place
Edinburgh EH8 9SU

7.4. "Reminder" Invitation

Dear Sir,

I am writing this letter to remind you of our recent request for your participation in the survey of ex-shale workers that is being conducted by this Institute.

The survey is of crucial importance to workers in new shale developments (such as in North America), since the results will help in future planning of safety measures. In this way the skin and chest ailments that affected Scottish shale and shale oil workers may be prevented. Even if you do not have any symptoms yourself, your cooperation in the survey is essential, to allow us to draw scientific conclusions. If you agree, you will be asked to fill in a short form of your health that we shall post to you. The information that you supply will be treated confidentially. Later, you may be asked to have an X-ray of your chest. If required, we will provide assistance with transport to our X-ray unit in your area. We shall send you a brief medical report on the X-ray on your request.

The survey includes all men who were members of the Scottish Oils Limited "1950 Provident Fund". This includes all workers at shale mines, retort works, refineries, acid works, detergent factories, candle factories, shale brick works, oil depots and jetties, and Middleton Hall. We are interested in all the health effects of the industry, including direct or indirect (e.g., watchmen, maintenance men, caretakers, etc.) exposure to dust, fumes, oils and waxes.

Please help us in this work by completing the enclosed form and return it in the envelope provided. I very much hope you will agree to assist us.

Yours sincerely

Dr A. Seaton
Director.

P.S. A raffle will be held for all those agreeing to take part and four hampers worth £25 each will be awarded to the winners.

Telephone 031 667 5131

Our Ref
Your ref

Institute of
Occupational Medicine

Roxburgh Place
Edinburgh EH8 9SU

7.5. Third Invitation format

Dear Mr.

This medical research institute has been asked to study the health of men who worked in the shale, oil and coal industries around Edinburgh. We should be grateful if you would agree to help us by participating in this research work.

The survey includes all men who were members of the Scottish Oils Limited 1950 Provident Fund. Records of that Fund indicate that you were a member during your employement at the BP Refinery, Grangemouth. Since the ultimate value of the survey depends largely on the participation of as many men as possible, your contribution will be of great value.

We shall post a short form to you, asking some questions about skin ailments which you might have had in the past. Even if you have not had skin problems, your contribution will still be valuable. The information that you supply will be treated confidentially.

During October you may also be asked to have an X-ray of your chest taken at our mobile unit in Grangemouth. If required, we will provide assistance with transport. We will send you a brief medical report on the X-ray on your request.

I very much hope you will agree to help. Please complete the questions below and return this letter in the stamped addressed envelope provided.

Yours sincerely

Dr A. Seaton
Director.

P.S. A raffle will be held for all those agreeing to take part and four hampers worth £25 each will be awarded to the winners.

I am prepared toanswer a short questionnaire on my health. (YES or NO) ______

I am prepared to attend for an X-ray of my chest. (YES or NO) ______

Name: ....

Address: ....

....

Tel.No: ....

Date of Birth: ....

NOTE: If you think that we have mistaken your identity for someone else's please help us by filling in your date of birth.

Office Use Only	
Number	
S	C

Telephone 031 667 5131

Our Ref
Your ref

Institute of
Occupational Medicine

Roxburgh Place
Edinburgh EH8 9SU

7.6. Invitation to colliery control population

Dear Sir,

As you know, this Institute has been performing X-ray surveys at collieries for many years and you were kind enough to cooperate in our survey in the early 1970's. You are no doubt aware of the fact that such surveys played an important role in making the coal industry safer for the miners. Your personal contributions to our survey were therefore of great value in the past.

At present we are doing a postal survey of the skin problems that afflict miners. We are particularly interested in men who were employed in the 1950's and 1960's and we are now contacting ex-employees of Morrison Busty colliery. It is very important that as many men as possible should take part in the survey. Therefore, we are once again requesting your cooperation with the Institute in this medical research. This survey entails only the enclosed questionnaire.

Please help us by completing the attached questionnaire as carefully as you can. The information that you provide will be held in strict confidence. We need to have all the forms back within 10 days, so please return yours as soon as possible.

Your help with this survey, as in the previous X-ray surveys, will be greatly appreciated.

Yours sincerely

Dr Anthony Seaton
Director

Telephone 031 667 5131

Our Ref
Your ref

A33

Institute of
Occupational Medicine

Roxburgh Place
Edinburgh EH8 9SU

7.7. Invitation to colliery control population sent via DHSS

Dear Sir,

As you know, this Institute has been performing X-ray surveys at collieries for many years and you were kind enough to cooperate in our survey in the early 1970's. You are no doubt aware of the fact that such surveys played an important role in making the coal industry safer for the miners. Your personal contributions to our survey were therefore of great value in the past.

At present we are doing a postal survey of the skin problems that afflict miners. We are particularly interested in men who were employed in the 1950's and 1960's and we are now contacting ex-employees of Morrison Busty colliery. It is very important that as many men as possible should take part in the survey. Therefore, we are once again requesting your cooperation with the Institute in this medical research. This survey entails only the enclosed questionnaire.

Please complete the questions below and return this letter in the stamped addressed envelope provided. (Even if you do not wish to participate in the survey, we would still require your answer, otherwise we would not know whether you have received this letter).

Your help with this survey, as in the previous X-ray surveys, will be greatly appreciated.

Yours sincerely

Dr Anthony Seaton
Director

I am prepared to answer a short questionnaire on skin conditions. (YES or NO) ______

Name: ....

Address: ....

....

Tel.No. (if any): ....

Date of birth: ....

Office use only	
Number	
S	C

CARD CLASS [S H 1] 1-3
REF. NO. [| | | | | |] 4-9

. First format - skin questionnaire

INSTITUTE OF OCCUPATIONAL MEDICINE

This medical research institute is carrying out a study of the health of men who worked in the Lothian shale and coal industries. I should be very grateful if you would help by answeri·g the questions below. Your answers will be treated in complete confi .ence by the doctors who are carrying out the study.

DR. ANTHONY SEATON

QUESTIONS: PLEASE ANSWER BY RINGING 'YES' OR 'NO' (for example YES (NO))

Question				FOR OFFICE USE COLS.
1. Do you have any skin trouble at present?	YES	NO	[ ]	10
2. Have you had any skin trouble during your adult life?	YES	NO	[ ]	11
If YES to either of the above questions, please answer the following:-				
3. Do you have or have you had (a) eczema	YES	NO	[ ]	12
(b) dermatitis	YES	NO	[ ]	13
(c) psoriasis	YES	NO	[ ]	14
(d) warts or moles	YES	NO	[ ]	15
(e) skin tumours or skin cancer	YES	NO	[ ]	16
(f) skin ulcers on your				
face	YES	NO	[ ]	17
hands or arms	YES	NO	[ ]	18
anywhere else on your body	YES	NO	[ ]	19
4. Do you, at present, have (a) an itching condition of your feet	YES	NO	[ ]	20
(b) any other skin condition or itch	YES	NO	[ ]	21
5. Have you ever had an operation to remove a lump, mole or ulcer of the skin?	YES	NO	[ ]	22
If YES, give approximate year of operation	19___		[ ][ ]	23-24
6. Have you ever had any treatment with X-rays or radium for a skin problem?	YES	NO	[ ]	25
If YES, give approximate year of treatment	19___		[ ][ ]	26-27
7. Have you ever worked in the coal industry?	YES	NO	[ ]	28
If YES, for how many years · Total	___yrs		[ ][ ]	29-30
Underground	___yrs		[ ][ ]	31-32
Surface	___yrs		[ ][ ]	33-34
8. What is your present occupation?	....			

Please write your Name ....

Address ....

....

Telephone number ....

Institute of Occupational Medicine

Skin Conditions : Morrison Busty Colliery
Second format - for controls

Important : Please return your answer without delay

for Office use

Instructions : Ring the correct answer for example : (Yes) No

1 Have you had any skin trouble during your adult life? Yes No

2 Do you have or have you had

- a. eczema? Yes No
- b. dermatitis? Yes No
- c. psoriasis? Yes No
- d. warts or moles? Yes No
- e. skin tumours or skin cancer? Yes No
- f. skin ulcers on your face? Yes No
  - or on your hands and arms? Yes No
  - or anywhere else on your body? Yes No

3 Do you, at present, have

- a. an itching condition of your feet? Yes No
- or b. any other skin condition or itch? Yes No

4 Have you ever had an operation to remove a lump, or mole, or ulcer of the skin? Yes No

If 'Yes', when? (give approximate year)

19.....

5 Have you ever had any treatment with X-rays or radium for a skin problem? Yes No

If 'Yes', when? (give approximate year)

19.....

6 Have you ever worked in the coal industry? Yes No

If 'Yes', for how many years? (approximately)

Total ....

Underground .....

Surface ....

7 What is your present occupation? ....

Please write your name ....

and address ....

....

and telephone number (if any) ....

Please check that all questions have been answered

7.10

CARD CLASS [S|H|2]

REF [| | | | |]

SMOKING QUESTIONNAIRE

Your Name:...................... Your Date of Birth:............

			FOR OFFICE USE
1.	Do you smoke? (Please write YES or NO)	______	10
	If NO		
2.	Have you ever smoked as much as one cigarette a day (or one cigar a week or an ounce of tobacco a month) for as long as a year? (YES or NO)	______	11
	If NO to both parts of question 1, omit remaining questions on smoking.		
3.	How old were you when you started smoking?	______	12-13
	How old are you now?	______	14-15
4.	Do you smoke manufactured cigarettes? (YES or NO)	______	16
5.	Did you smoke manufactured cigarettes in the past? (YES or NO)	______	17
	If YES to either of the above questions		
6.	How many do (or did) you usually smoke per day on weekdays?	______	18-19
7.	How many do (or did) you usually smoke per day at weekends?	______	20-21
8.	For how long have (or had) you been smoking that many?	______ Yrs.	22-23
9.	What is (or was) the greatest number of cigarettes you ever smoked regularly per day?	______	24-25
10.	For how long have you been (or were you) smoking that many?	______ Yrs. or ______ Mths.	26-27
11.	Since you started smoking cigarettes have there been periods during which you did not smoke? (YES or NO)	______	28
12.	If YES for how long altogether were you not smoking cigarettes?	______ Yrs. or ______ Mths.	29-30
13.	Do you smoke hand-rolled cigarettes? (YES or NO)	______	31
14.	If NO, did you smoke hand-rolled cigarettes in the past? (YES or NO)	______	32
	If YES to either of the above questions		
15.	How much tobacco do (or did) you usually smoke per week in this way?	______ Oz.	33-34
16.	For how many years have you smoked (or did you smoke) hand-rolled cigarettes?	______ Yrs.	35-36

			FOR OFFICE USE
17. Do you smoke a pipe (more than one ounce of tobacco a month)? (YES or NO)	________		37
18. If NO, did you smoke a pipe in the past? (YES or NO)	________		38
If YES to either of the above questions			
19. How much pipe tobacco do (or did) you usually smoke per week?	________	Oz.	39-40
20. For how many years have you smoked (or did you smoke) a pipe?	________	Yrs.	41-42
21. Do you smoke cigars (more than one a week)? (YES or NO)	________		43
22. If NO, did you smoke cigars in the past? (YES or NO)	________		44
If YES to either of the above questions			
23. How many of these do (or did) you usually smoke per week?	________		45-46
24. For how many years have you smoked (or did you smoke) cigars?	________	Yrs.	47-48
For ex-smokers:			
25. At what age did you last give up smoking?	________	Yrs.	49-50

Thank you for answering these questions; your contribution will be of great value to our study.

Telephone 031 667 5131

Our Ref
Your ref

Institute of
Occupational Medicine

Roxburgh Place
Edinburgh EH8 9SU

7.11. Invitation to men to participate in PFT survey

Dear Mr.

As you know, this Institute is currently doing medical research on the health of ex-workers of the shale, coal and refinery industries. Indeed, you were kind enough to volunteer for an x-ray of your chest last year. Your contribution to our research has been of great value and it would appear that some important conclusions should arise from this work.

We are now ready to commence the last survey of this research project and I wonder whether we might, once again, call on you for your help. This survey comprises some breathing tests only. (There will be no further X-rays or questionnaires). Our survey van will be stationed at the Pumpherston Detergent Factory and our research team will, as before, provide you with transport, if required. Specific appointments will be given so that we should not take up more of your time than is necessary for the tests.

Please note that this work is very important and its success depends, to a great extent, on your personal contribution. Even if you think that your breathing is not very good, it would still be important for us to see you, because we need to survey men with all degrees of health.

Our survey team will call on you during the next week to give you an appointment. I hope you will agree to cooperate in this work.

Yours sincerely

Dr A. Seaton
Director.

Appendix 7.12

INSTITUTE OF OCCUPATIONAL MEDICINE

SHALE STUDY - RESPIRATORY SYMPTOMS DATA

Surname
Forenames

IOM Ref

Preamble "I am going to ask you some questions about your chest - about cough and spit, for example. Please try to answer YES or NO. Your answers will be treated confidentially."

1. Do you cough when you get up, or first thing in the morning? ___

If question 1 is YES, then ask question 2
2. Do you cough like this on most days for as much as 3 months in the year? ___

3. Do you cough during the rest of the day? ___

If question 3 is YES, then ask question 4
4. Do you cough like this on most days for as much as 3 months in the year? ___

5. Do you bring up phlegm when you get up, or first thing in the morning? ___

If question 5 is YES, then ask question 6
6. Do you bring up phlegm like this on most days for as much as 3 months in the year? ___

7. Do you bring up phlegm during the rest of the day? ___

If question 7 is YES, then ask question 8
8. Do you bring up phlegm like this on most days for as much as 3 months in the year? ___

9. Do you have to walk slower than other people on level ground because of your chest? ___

10. Do you ever have wheezing or whistling in your chest? I don't mean only when you have a cold. ___

11. Does the weather affect your chest? ___

12. In the last 3 years have you had a chest illness that has kept you from your usual activities for as much as a week? ___

If question 12 is YES, then ask question 13
13. What did your doctor say it was?

1st. such illness ___

2nd such illness ___

3rd. such illness ___

(A = Asthma; B = Bronchitis; C = Cold; D = Bronchitis & Asthma; E = Influenza; F = Some other chest illness; G = Chest injury)

Appendix 8

COMPUTER-ASSISTED VALIDATION OF SMOKING AND DERMATOLOGY QUESTIONNAIRES

For both questionnaires, two types of checks are applied. Each answer is examined individually - if it falls outside the range of valid values which apply to that answer, the questionnaire is rejected and not entered into the database. combinations of answers to different questions are then examined - if they satisfy at least one of the rejection conditions established for the questionnaire then it will be rejected and not entered into the database.

1. Dermatology questionnaire

1.1 Valid ranges

(1) All YES/NO questions must be 1 (YES), 2 (NO), or blank (missing).

(2) The dates in questions 5 and 6 must be 0-83 or blank (missing).

(3) No valid ranges have been specified for the answers to questions 7 or 8; the only examination of these answers is to recognise blanks as missing values.

Note that any answers to questions 1-6 coded as -8 (unintelligible) will result in the questionnaire being rejected.

1.2 Rejection conditions

The 8 "reject rec if" conditions are as follows:

1. answers 1 or 2 missing

2. answers 1 or 2 'YES', but at least one other missing

3. answers 1 and 2 'NO', but some others indicate skin trouble (i.e. at least one part of questions 3 or 4 or 5 or 6 is 'YES')

4. answers 1 and 2 'NO', some of answers 3 to 6 missing, and they do NOT fall into one of these 3 patterns:
   - just whole of answer 3 missing
   - just whole of answers 3 and 4 missing
   - just whole of answers 3, 4, 5 and 6 missing

5. answer 5 'YES', but no operation date given

6. answer 5 'NO', but operation date is given

7. answer 6 'YES', but no treatment date given

8. answer 6 'NO', but treatment date is given

2. Smoking questionnaire

2.1 Valid ranges

(1) All YES/NO questions must be 1 (YES), 2 (NO), or blank (missing).

(2) Questions 2 (age when started smoking) and 8 (age when last gave up smoking) must be 0-99 or blank (missing).

(3) Questions 4(a).I, 4(a).II, 4(b).I (cigarettes smoked daily) must be 0-150 or blank (missing).

(4) Questions 4(a).III, 5(b), 6(b), 7(b) (number of years smoking) must be 0-99 or blank (missing).

(5) Questions 4(b).II, 4(c).II (number of years and months) must be 0-99 years 11 months or blank (missing).

(6) Questions 5(a), 6(a) (oz tobacco smoked) must be 1-9.9 or blank (missing).

(7) Question 7(a) (number of cigars) must be 0-99 or blank (missing).

Note that any answers coded as -8 (unintelligible) will result in the questionnaire being rejected.

2.2 Rejection conditions

The 15 "reject rec if" conditions are as follows:

1. answer 1 missing, or answer 1 'NO' and answer 1(a) missing

2. answers 1 and 1(a) 'NO', but other answers show respondent is/was a smoker.
(i.e. non-zero answer to at least one of questions 4(a), I - 4(a). III, 4(b). I - 4(b).II, 4(c),II, 5(a), 5(b), 6(a),. 6(b), 7(a), 7(b); or 'YES' to at least one of questions 4.I, 4.II, 5.I, 5.II, 6.I, 6.II, 7.I, 7.II; or a non-missing answer to question 2 or 8)

3. answer 1 or 1(a) 'YES' (i.e. a smoker) but some compulsory smoking questions omitted
(i.e. at least one of questions, 2, 4.I, 4.II, 5.I, 6.I, 7.I not answered; or answer 5.I 'NO' and 5.II omitted; or answer 6.I 'NO' and 6.II omitted; or answer 7.I 'NO' and 7.II omitted)

4. smoker and answers, 4.I, or 4.II "YES', but other parts of question 4 omitted, or they show no manufactured cigarette smoking.
(i.e. a missing answer to at least one of questions 4(a). I-4(a),III, 4(b),I-4(b).II, 4(c).I; or 4(a).I plus 4(a).II equal to zero; or at least one of 4(a).III, 4(b).I, 4(b).II equal to zero; or 4(c).I 'YES' and 4(c).II missing or equal to zero)

5. smoker and answers 4.I and 4.II 'NO', but other answers show manufactured cigarette smoking (i.e. at least one of answers 4(a).I - 4(a).III, 4(b).I, 4(b).II greater than zero; or 4(c).I not missing)

6. smoker and answers 5.I or 5.II 'YES', but other parts of question 5 omitted, or they show no hand-rolled cigarette smoking (i.e. 5(a) or 5(b) missing or equal to zero)

7. smoker and answers 5.I or 5.II 'NO', but other answers show hand-rolled cigarette smoking (i.e. 5(a) or 5(b) greater than zero)

8. smoker and answers 6.I or 6.II 'YES', but other parts of question 6 omitted, or they show no pipe smoking (i.e. 6(a) or 6(b) missing or equal to zero)

9. smoker and answers 6.I and 6.II 'NO', but other answers show pipe smoking (i.e. 6(a) or 6(b) greater than zero)

10. smoker and answers 7.I or 7.II 'YES', but other parts of question 7 omitted, or they show no cigar smoking (i.e. 7(a) or 7(b) missing or equal to zero)

11. smoker and answers 7.I and 7.II 'NO', but other answers show cigar smoking (i.e. 7(a) or 7(b) greater than zero

12. smoker but other answers show no cigarette, pipe or cigar smoking (i.e. all of 4.I, 4.II, 5.I, 5.II, 6.I, 6.II 7.I, 7.II 'NO')

13. ex-smoker, but age when last gave up smoking is missing or zero (i.e. answer 1 'NO' but 1(a) 'YES', and answer 8 missing or zero)

14. current smoker, but age when last gave up smoking is greater than zero (i.e. answer 1 'YES' and answer 8 greater than zero)

15. age when last gave up smoking (answer 8) less than age when started smoking (answer 2)

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