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Final Report

VOLUME 2

MORTALITY IN THE SCOTTISH SHALE MINING COMMUNITIES

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VOLUME 2

MORTALITY IN THE SCOTTISH SHALE MINING COMMUNITIES

by

Sara C Randall, Hilary A Cowie, JF Hurley, M Jacobsen

ABSTRACT

This study aimed to identify any adverse impact of the shale industry on mortality in communities in Scotland where oil shale was extracted and processed until 1962, when the industry closed.

Civil Parishes in the study area were classified as 'Shale', 'Coalmining' or 'Rural' according to levels of shale and coal industry activity during or shortly before those periods over which mortality was monitored. Information about the population at risk in these areas, and mortality, was obtained primarily from official sources, supplemented by *ad hoc* investigations of specific problems.

Mortality analyses focussed on malignant causes 1953-81 and non-malignant causes 1963-81; mortality from all causes, 1911-31, was also examined.

There was no evidence that mortality 1911-31 among men or women in the shale areas was higher than in coalmining areas locally, or in selected other Scottish regions. Among men, non-malignant mortality 1963-81 was higher in the shale than in other industrial areas, probably reflecting social factors (e.g. unemployment following decline of the shale industry) rather than a direct effect of previous shale production. As anticipated, there was excess mortality from pneumoconiosis in the coalmining parishes, and from skin cancer in the shale areas. Other analyses of malignant causes 1953-81 suggested increased risks of bladder cancer and (among men) of other genito-urinary cancer in parishes where the shale industry had been concentrated.

1. INTRODUCTION

1.1 Underlying Rationale

Increased awareness in the 1950s of the need to husband all sources of energy and to exploit indigenous fuels maximally led to renewed interest in the rich oil shale deposits in the north western parts of the United States of America. By the end of the decade a considerable expansion of that industry was being contemplated, and this prompted a search for quantitative information about possible shale-associated occupational and environmental risks to health that might accompany such a development (Weaver and Gibson, 1979).

1.2 Occupational Mortality and Morbidity in the Scottish Shale Industry

New information became available in 1985 with the publication of three volumes describing research into the now extinct Scottish shale industry (Seaton, 1985). Extraction of oil shale began in Scotland in 1850, reached a peak in 1913, and declined subsequently until the industry closed in 1962, when extraction of oil from Scottish shale was no longer viable economically. The work reported by Seaton (1985) included a description of the industry's technical development, a review of available information about dust conditions and safety precautions in the mines, a comparison of Scottish shale mineralogy with that of deposits in the Green River formation of the Colorado Rockies, and accounts of morbidity and mortality studies among men who had been employed in the industry.

The population considered in the latter epidemiological studies was defined from records of a Provident Fund that was set up in the early 1950s for all employees of Scottish Oils Ltd. That scheme included, effectively, all those who worked in the industry from 1950 onwards. More than 6000 members of the Provident Fund were identified.

Causes of death were studied among some 2500 of those who had died before 1983 (Miller *et al*, 1986), and estimates were made of the prevalence of pneumoconiosis and of skin conditions in a sample of survivors (Seaton *et al*, 1986). An excess of deaths from skin cancer was found among men who had worked with shale before 1953, but there was no excess of skin diseases among survivors. Exposure to shale dust in mines and at retorts was associated with pneumoconiosis. The prevalence of this condition was low among the survivors studied (Seaton *et al*, 1986), but men with pneumoconiosis had poorer lung function than their peers with no pneumoconiosis (Louw *et al*, 1986).

There were no suggestive patterns of cause-specific mortality associated with different jobs within the industry, and comparisons with death rates for the local area showed no excesses for any of the common causes of death that were considered. A supplementary case-control study of patients at a local hospital failed to show any excess risk of lung cancer among men who had worked in the shale industry or among those who had lived in areas where shale activity had been relatively high (Miller *et al*, 1986).

1.3 The Desirability of Community Studies

The size and statistical power of the Provident Fund-based mortality study make it unlikely that any major effect of work in the industry on mortality was missed (Miller *et al*, 1986). It is a fact however that any study based on membership of the Provident Fund includes only those who worked in the industry after 1950; by definition, anyone who left the industry before that date was not included. If it is assumed that working conditions tended to improve over the years, then individuals who left the industry before 1950 are more likely to have been exposed to noxious agents, during the period of the industry's peak activity, than those who were eligible for membership of the Provident Fund. Results from studies based on membership of the Fund may therefore not reflect adequately the potential hazards of exposure to shale and its products.

Consideration was given therefore to the possibility of conducting a wider based investigation of mortality in communities embracing and adjacent to the area where the industry had been located. It was hoped that such a study might include many who had left the industry before 1950, and that it might therefore better reflect the effects of conditions when the industry was at its peak. Such research would also place into a broader perspective results from the two studies based on the Provident Fund, by describing more generally the impact of the shale industry on the health of the communities concerned. In particular, it was thought, a community mortality study might provide information about possible environmental, as distinct from occupational, hazards to health that may be associated with extraction and processing of shale.

The feasibility of this idea was established in a series of exploratory investigations (Marine *et al*, 1982). It was found that small geographical areas corresponding to varying intensities of shale activity in the counties of Midlothian and West Lothian could be identified; that the populations living in those areas were identifiable from census returns; and that a computer file of deaths specific to those areas was in existence, at least from 1963 onwards and, for cancer deaths, from 1953. Subsequent enquiries strengthened confidence in the viability of the idea and detailed plans were made accordingly. The work was carried out, and is reported here.

1.4 Aim and Objectives

The broad aim was to identify shale-related health hazards that may have been present in Scottish communities involved in the extraction and processing of oil shale before the industry closed in 1962. More specifically, efforts were to be made to acquire as much information as possible about cause-specific mortality in small areas of Midlothian and West Lothian so as to identify patterns associated with differences in levels of shale production at various times and places; that is, any patterns which might indicate industry related health hazards among workers who had been employed in the shale industry and, more generally, among people who had lived in the communities concerned.

2. METHODS

2.1 Calendar Periods Studied

The original plan was to consider cause-specific mortality in the areas of interest from 1963 through 1981, and cancer deaths from 1953 onwards, because the relevant records of deaths for those, but not earlier, periods were available on computer tapes compiled by the Registrar General (RG) for Scotland. Subsequent enquiries established that it would be feasible also to document overall (but not cause-specific) mortality in the shale communities and neighbouring non-shale areas for 1911-31, by extracting death records manually from manuscript death registers held centrally in Edinburgh. It proved possible to organise these data so that they could be grouped into shale activity specific areas for analyses of overall mortality differentials during the period 1911-31; and so they too were included in the study.

2.2 Acquisition of Background Information

Supplementary data on life in the shale areas, and on factors which might have affected mortality patterns independent of shale activity level, were obtained through a series of 31 semi-structured interviews with older residents in the area (Randall, 1990). This material provides qualitative descriptions of those aspects of life which are likely to have affected both morbidity and mortality in the communities. The information was partly to guide decisions on how to define the shale areas for analysis and also to help interpret the results from the analyses. Much of the information referred to below, which informed decisions about areas for analysis and factors to be taken into account in the analysis, was obtained from these interviews.

2.3 Definition of Small Areas for Study

2.3.1 Choice of Civil Parish as a Basic Unit of Analysis

The shale industry, both mines and oil works, operated over a limited area in Mid and West Lothian. At its inception in the 1860s the industry was located only around Bathgate, but by the 1870s small oil companies were operating over the whole area of the shale field (Figure 2.1). The area exploited for shale is not conterminous with any local boundaries, and within each of the two counties concerned there were, and are, other heavy industries, mainly coalmining, which had to be taken into consideration.

In principle, analyses of mortality could have been based on any of three levels of administrative area: Districts of County, Civil Parishes (CPs) and Registration District (RDs). (In general there are one to three RDs in a CP, and one to three CPs in a District of County). It was thought originally that Districts of County would be the best choice, because both population and death data were published at that level, but further investigations showed that they were rather heterogenous with respect to shale activity. Registration Districts are the smallest defined areas; but although their boundaries are recorded in descriptive terms, they are not available on maps, they were changed frequently over the years, and no population age structures are published for them, (although total populations by sex were available until 1931).

It was decided therefore to use Civil Parishes as the basic units of analysis: with one or two exceptions they were relatively homogenous with regard to shale and other industrial activity; their boundaries never changed, and, for the majority of censuses, age–sex distributions of the population were available. Mortality analyses by individual CPs were not attempted, despite the availability of shale activity data at that level, because the majority of CPs are too small (populations range from about 300 to 12000). Instead, it was decided to group them together into different 'shale industry activity areas', according to level of shale and other industrial activity.

2.3.2 The Shale Industry Study Area

The area of study ('The shale industry study area') was defined as the whole of West Lothian and part of Midlothian comprising 17 Civil Parishes (Figure 2.1), with Kirkliston (West Lothian) and Kirkliston (Midlothian) qualifying as separate CPs. It included several non–shale CPs, for use in comparative analyses.

2.3.3 Groupings of Civil Parishes by Level of Shale Activity

The shale mines, and the oil works where the shale was retorted, were the main workplaces and possible sources of contact with shale products for the general population. The bings (slag heaps) where the spent shale was dumped produced much dust (Randall, 1990), and the shale oil works were also a source of atmospheric pollution. Two candle works and a sulphuric acid works were also associated with the industry.

Data were obtained from the British Petroleum Archives at Grangemouth on the amount of shale produced at each mine annually from 1919–1963, and the amount that went through each oil works. This information was amalgamated according to location of the mines or oil works into a production and throughput index per civil parish (Figure 2.2). These shale production and throughput statistics were used in conjunction with information obtained at interviews to generate high, low and no shale industry activity areas comprising groups of civil parishes (Appendix 1). The assumption was that the more shale an area produced, the more likely it would be that the population concerned would have had either direct or indirect contact with the material or its by–products, either through contact in daily life, through work activity or through atmospheric pollution generated by the oil works.

Different classifications of Civil Parishes were used for the two time–periods 1911–31 and 1953–81, because of temporal changes in the intensity of production and throughput (Figure 2.2). For the earlier period, 1911–31, it was possible to form the CPs into 4 groups: High Shale (HS), Low Shale (LS), No Shale–Industrial (NSI) and No Shale–Rural (NSR). In the 'High Shale' area shale mining and processing was the dominant industry, with many of the villages effectively being company towns. 'Low Shale' civil parishes contained some shale activity but also included large areas which were dependent on agriculture or other industries. 'No Shale–Industrial' civil parishes had little or no shale industry, but other heavy industry and coalmining formed the major part of the economy whereas 'No Shale – Rural' parishes were predominantly agricultural but also included paper mills and quarries. Further details of the classifications adopted are included in Appendix 2.

An alternative grouping of CPs for the period 1911–31 was formed following preliminary analysis of death rates. These had indicated that there was very little difference in mortality levels between high and low shale areas. The distinction between high and low shale was therefore abandoned, to give three groups only: Shale, Coal and No Shale (NS). This was effected primarily by redistribution of the former Low Shale CPs, though one 'No Shale–Industrial' parish was also re-classified, as 'No Shale' (Table 2.1). Both classifications are used in the results presented below.

For the 1953–81 analysis, decisions on how areas were to be classified were made by considering 'lagged' shale activity. For most of the period the shale industry was not operating, but as the main interest was in cancer mortality, and cancer has a long latent period, shale activity 20 years earlier was taken as the measure of relevant activity – 'lagged activity' (Appendix 1). A threefold classification was used, Shale, 'No Shale Industrial' and 'No Shale Rural', based on similar criteria as above.

2.4 Areas for External Comparisons of Mortality

For 1953–81, data were also available for comparisons of mortality between the shale study area, and other parts of Scotland. Areas for external comparisons of mortality were selected because of particular characteristics which it was thought might throw light on possible environmental effects (Figures 2.3a, 2.3b). Some census data are available which indicate the importance of different industries in these comparison areas: numbers who work in particular industries and specific occupations (Table 2.2). Coalmining and foundries were considered to be the most important of the possible confounding industries for this study.

2.4.1 The Borders

The Borders (population 1971=101,735, 1981=97,218; General Register Office (Scotland): 1971, 1981 Censuses) is a rural area in the south of Scotland, where there has never been any heavy industry. There is a strong tradition of textile manufacture, which until recently provided employment for a substantial proportion of the working population not engaged in agriculture. It is also an area to which people retire, and with few employment opportunities for young people, it has an old age structure.

2.4.2 Fife

Fife (population 1971=327,130, 1981=325,066; General Register Office (Scotland): 1971, 1981 Censuses) is an area traditionally associated with coalmining, although like the shale area, much of the mining region is interspersed with rural agricultural communities. Along the coast are fishing communities, and in some of the larger towns a whole series of other industries occur. It resembles the shale area in the heterogeneity of industrial opportunities and living conditions.

2.4.3 Midlothian

Before local government reorganisation in 1974, Midlothian county (population 1971=142,210, 1981=81,680; General Register Office (Scotland): 1971, 1981 Censuses) contained some of the shale civil parishes, although they formed only a small part of the county as a whole. The other major industry is coalmining, Midlothian containing the coalfield to the south of Edinburgh. Because of its proximity to Edinburgh, certain areas are commuter belt zones for those who work in the city.

2.4.4 Scotland

Many of the external comparisons of mortality were made with Scotland as a whole. The Scottish population is distributed very unevenly, with about two thirds living in the Greater Glasgow conurbation. Parts of this area are well known for their poverty and ill health, with high morbidity and mortality; for example, the incidence of lung cancer 1975-1980 among males in Glasgow City was the highest recorded in the world (Kemp *et al* 1985). Cause-specific death rates in Scotland as a whole may therefore be expected to be raised relative to those in the shale study area.

2.5 Population Data

All population at risk data were obtained from Scottish decennial censuses. For some census years civil parish age sex distributions were readily available. In others however they had to be obtained from a variety of sources (Table 2.3).

2.5.1 Adjustments of Population Census Data

All published census data, except those for 1981, were based on *de facto* populations (all individuals enumerated where they were on census night); the 1981 census referred to the *de jure* population (the usually resident population). Thus, apart from 1981, hospital patients, shipping personnel, members of the Armed Forces as well as casual visitors are all considered to be part of the population where they were located on census night. In general, casual visitors are unlikely to introduce a major bias because they are small in number and can be assumed to be balanced by those away. However, the other groups tend to be concentrated in one sex and a few age groups, and they may thus cause distortions in the populations which are not reflected in the death data which are allocated to areas on a *de jure* basis.

Adjustments were made for these potential biases in the estimates of the size of populations at risk by removing from the census populations the estimated numbers of surplus individuals. The total populations for hospitals, shipping and Armed Forces were available at county level, and in some cases the age distribution was also available. In cases where the age distribution was not published, another appropriate age distribution was found (e.g. that of all Forces in Scotland, admissions to Bangour Hospital in the census year) and the surplus population concerned was distributed proportionately, and the numbers, by age-group and sex, subtracted from the census population to give the estimated numbers at risk.

2.5.2 Estimates of Annual Populations at Risk

Annual populations at risk were estimated using linear interpolation between the decennial census populations, after the above adjustments had been made. The estimates were made for each five-year age group in each civil parish, after which the appropriate civil parish populations were added together to form the estimated populations at risk for each shale activity area, as at June 30 each year.

In most cases the civil parish populations changed little over the ten-year periods and linear interpolation was judged appropriate. This was verified for the period 1961-71 using data from the sample census conducted in 1966 (Appendix 3). The exceptions were in the civil parishes where Livingston New Town was located. Construction of the New Town started in the mid 1960s and in the second half of the decade the population boomed. In this case the populations at risk in the civil parishes concerned were estimated separately for two five-year periods (1961–66 and 1966–71) by interpolation based on the 1966 sample census data.

2.6 Mortality Data

2.6.1 1911-31

Mortality data for 1911-1931 were all extracted from the (manuscript) statutory death registers kept in Register House, Edinburgh. Every death was entered in the register with the name of the deceased, name of parents, age, sex, occupation (if male), usual residence, place of death if different from usual residence, cause of death and duration of illness. All the registration districts in the shale study area were consulted for each year; age at death and sex were noted for every death recorded.

Until 1966 all deaths in Scotland had to be registered in the registration district where the death occurred and not in the RD of usual residence. Hence deaths of all individuals not normally resident in the registration district were recorded separately and allocated afterwards to their place of usual residence. In order to locate deaths of people normally resident within the shale study area, but who died elsewhere, the registers containing the principal hospitals in Edinburgh, Glasgow, Falkirk and Stirling were also searched, as was Athelstaneford which contained the East Fortune TB sanatorium.

Annual published distributions of deaths by age and deaths by sex (but not the two simultaneously) were available at burgh and county landward area level (Registrar General of Scotland's Annual Reports: 1911-31). and thus the overall level of tracing could be checked. Between 92% and 96% of deaths were traced for each year (Appendix 4). Correction factors were calculated, to adjust for untraced deaths, when mortality in the shale study area was compared with death rates elsewhere in Scotland. It was impractical to make similar adjustments for comparisons of mortality between shale activity areas; and there was in any case no reason to suppose that omissions were related to shale activity area.

2.6.2 1953-81

Computerised individual records of all cancer deaths in Scotland for 1953–62, and all deaths in Scotland for 1963-81, were made available by the Registrar General (Scotland). All records were coded according to the conventions required at the time of death, in terms of areas of usual residence, cause of death (ICD code), and occupational group (Table 2.4). Each record contained an individual identification enabling the death to be located, and if necessary traced, in the registers held at Register House, Edinburgh. The whole file was checked to see that the codes fell within the possible ranges, and that there were no obvious inconsistencies. Apparent anomalies were compared with the original register entry and corrected where necessary.

Because these data were copies of statutorily recorded deaths, they are a complete record of all deaths that occurred, within the limitations of the Scottish collection system. A few cases of missing data were identified and where possible these were verified and corrected from the entries in the registers. The areas to which deaths were allocated for usual residence were not consistent throughout the period and these were recoded manually (where necessary).

2.6.3 Classification of Death Data by Small Area

As the study involved analyses of death rates in small areas it was essential that the recorded deaths were allocated accurately to the place of usual residence. For the 1911–31 data this allocation was effected at the data collection stage, where deaths of individuals usually resident elsewhere than in the registration district concerned were allocated to their place of usual residence. For the 1953–81 data this allocation was also possible, since one code on the data tape referred to 'usual residence'. However, the areas which were coded were dictated by the requirements of published statistics at the time. These varied considerably (Table 2.5) and were rarely in small enough units to be defined accurately in terms of shale activity. Thus all deaths on the RG's data file which were known to have occurred to usual residents of the shale study area, but were not readily identifiable in terms of civil parish of usual residence, were listed and then checked in the death registers. The actual usual residence address was recorded and then recoded manually to the civil parish level.

2.6.4 Mortality Data for Reference Populations

Equivalent data for the reference populations were also extracted from the tapes supplied by the Registrar General.

2.6.5 Grouping of Causes of Death

The causes of death on the computer file for 1953–81 were coded according to ICD Revisions 6, 7, 8 and 9 into three and four digit codes. In order to obtain comparability between revisions and to reduce the number of causes being investigated, the codes were grouped together into 34 cause groups, the majority of which were identical with the ICD large divisions. Some causes which were thought to have possible associations with shale were considered separately, as detailed in Appendix 5.

2.7 Methods of Analysis

2.7.1 Age-specific and Age-standardised Indices of Mortality

Standard indices were used for descriptive purposes, as described for example by Breslow and Day (1987, Ch 2). Overall mortality was described primarily by directly standardised death rates, specific to age (5– or 10–year groups), sex, and calendar time-period (annually, or in approximately 5-year groups). For example, the six time-periods (1953–57, 1958–62, 1963–67, 1968–72, 1973–78, 1979–81) used for presentation of rates 1953–81 were defined so that the same revision of the ICD coding was used within each period. On the other hand, corresponding Figures are based on a smoothed three point running mean of the annual rates, year-by-year data being too unstable for the discernment of trends.

Results were aggregated over all ages, or restricted to ages 15–74 years.

The age distribution of the whole shale study area in 1921 was used as the standard for the 1911–31 period; and that of all Scotland 1961 population was used for standardisation 1953–81. Thus, it is possible to examine trends with time, within each of the two main periods of calendar time; but comparisons of standardised rates across periods are not legitimate.

Descriptions of cause-specific mortality 1953-81 used Standardised Mortality Ratios (SMRs) and Comparative Mortality Figures (CMFs), and associated standard errors (Breslow and Day, 1987). These were calculated for the 34 cause groups listed in Appendix 5, by sex and by time-period, for all ages and for ages 15-74 years. Scottish rates were used as the standard for the SMRs and the whole Scotland population was taken as the standard population for the CMFs. Both indices of relative mortality were examined in the preliminary analyses, as a precaution in case heterogeneous age distributions in the populations at risk should combine with variations in age-specific relative risk to give misleading average figures over all ages. However, only the SMR results are reported because the two indices gave similar answers throughout.

Mortality odds ratios (MOR) were also calculated for each cause group as indices of proportional mortality less dependent on the relative numbers of deaths attributed to different cause groups than the Proportional Mortality Ratio (Miettinen and Wang, 1981).

2.7.2 Life Tables

(All-cause) mortality 1911-31, by shale activity area, was also examined using life tables calculated from age specific mortality rates at ages <1, 1-4, 5-9, 10-14, 15-24, 25-34,....85+).

(i) Calculation and Reliability

Numbers of births in each civil parish were estimated by allocating, proportional to population, the published numbers of births at burgh and county district level, and an estimate of infant mortality rates was derived. (The underlying assumption, that fertility did not vary within a county district, was probably not valid: the age-sex distribution of the 'no shale rural' populations indicated that fertility was lower there than in the adjacent shale communities, and so the estimates of infant mortality are probably lower in the 'no shale rural' area, and higher elsewhere, than was really the case.)

The age specific mortality rates (nMx) were converted into 9x (the probability of dying) using the formula:

$$ {}_nq_x = \frac{2_n({}_nM_x)}{2+_n({}_nM_x)} \quad , \quad {}_n9_x = \frac{2_n({}_nM_x)}{2+_n({}_nM_x)} $$

where n is the interval length and the subscript x refers to the age at the start of the interval n. The first interval (birth to exact age 1) was calculated by dividing it into 0.3 and 0.7, assuming that half the infants died in the first 3.6 months; the second interval was divided into 0.4 and 0.6 assuming that young children were more likely to die towards the beginning of the age group 1 to 4 years.

(ii) Summary Indices

The principal life table measures presented below are $\mathring{e}_0$, $\mathring{e}_{15}$, and the probabilities of dying between certain ages, where $\mathring{e}_0$ is the expectation of life at birth. Its general usefulness in summarising the whole mortality experience is lessened in this study because differences in infant and child mortality may mask the adult mortality differences which are of primary interest whilst the infant mortality measures are the least accurate. However $\mathring{e}_0$ is the expectation of life at age 15, and so is unaffected by any errors or differences in death rates at earlier ages.

The symbol nqx denotes the probability of dying between age x and age x+n, and so it describes mortality patterns and levels at various stages in life. Because this study is particularly focussed on excess mortality that might be associated with the shale industry, mortality at older ages, especially after age 75, is relatively unimportant. The probabilities of dying between 15 and 65, and 15 and 75 are good measures of adult mortality and they are most likely to reflect hazards during working life.

(iii) Smoothing

The shale activity areas had relatively small populations, and when age specific mortality is calculated, even for five-year periods, quite large random fluctuations remain. These are most prominent for young adults when the death rates are lowest, and when examining the probabilities of dying in restricted age intervals, they can mask the true trends. For this reason the life tables were smoothed using a logit transformation.

It has been shown empirically by (eg. Princeton University (1968)) that for two life tables, the logits [0.5ln((1−p)/p] of the *l*x values, where *l*x is the proportion surviving at each age, lie in an approximate straight line. This finding can be used to smooth out irregular life tables. Here the published life tables (by sex) for Scotland 1920–22 (Registrar General Scotland) were used as the standard. The logits of the standard were fitted to those of each five-year shale activity area life table using regression and the regression coefficients used to estimate fitted logit(*l*x)s from which *l*x and all the other life table measures were calculated. These are the basis for all the probabilities of dying presented in Section 3.2.

2.7.3 Log-linear Modelling of Rates

The summary descriptions of mortality were supplemented by fitting log-linear models of relative hazards to the grouped mortality data (Holford, 1980). This regression-like procedure, related to the calculation of SMRs (Breslow and Day, 1987, Ch 4), produces an estimate, with appropriate standard error, of the relative hazard of all-cause or cause-specific mortality in one study group relative to another (or to a reference population). It is not however necessary to assume that one of populations being compared is a reference population with negligible statistical variation and so the log-linear approach is especially useful when study groups are small. In addition, it allows great flexibility for testing whether an estimated relative risk is constant over age groups or calendar periods, and for the simultaneous comparison of more than two populations; and it extends straightforwardly to models which examine the effects of belonging to different birth cohorts as well as those of age and calendar year (Osmond and Gardner, 1982).

Following Holford (1980), the models used here fit linear functions of explanatory variables to logarithms of observed death rates, assuming Poisson error. The models were fitted, and associated relative risks estimated, by maximum likelihood methods, using the Genstat statistical language (Alvey *et al*, 1983) on a PRIME 750 computer.

2.7.4 Cohort Analysis

The summary descriptions of death rates classified by age, sex and time-period, and the associated log-linear analyses, were extended for selected causes of death to include the mortality experiences of different birth cohorts within the shale area, and to compare these with the experience of those in the adjacent no-shale areas. As address at death was the only spatial variable available for the death data, proper birth cohorts defined by place and years of birth were unavailable: instead place of death was used as a surrogate for place of birth and life time experience, with cohorts defined by year of birth.

The method of organising the cohort deaths and populations at risk followed that outlined by Case (1956). Cohort mortality rates were calculated for selected causes, for the period 1953–81 (malignant causes) and for 1963–81 (non-malignant causes and all causes). All-cause data 1911–31 were also available, but are not reported here. Five-year birth cohorts were used, distinguishing those born in the periods 1883–87, 1888–92, 1893–97, and so on. In the analysis, cohorts were used only where complete information for an age group was available.

Age at death in single years was available 1953–81, and thus the number of deaths in each cohort while it is passing through a five-year age group could be calculated exactly. A five-year birth cohort takes nine years to pass completely through a five-year age group although different weights are attached to each of those years. The entire cohort lies within a single age group only on the fifth or pivotal year of the nine-year passage. Choice of five pivotal years (1957, 1962, 1967, 1972, 1977) for the period 1953–81 maximised the number of measures available for each cohort. An illustrative example is given in Appendix 6.

Ideally the same method would be used to estimate populations at risk, but single year population figures were not available. On the assumption that throughout the nine-year period each five-year age group is rectangular (with 1/5 total population at each single year of age) the population at age x to x+4 in pivotal year y was calculated as follows:

$$P(x,x+4)y = 1/5P(x,x+4)y-4 + 2/5P(x,x+4)y-3 + 3/5P(x,x+4)y-2 + 4/5P(x,x+4)y-1 + P(x,x+4)y + 4/5P(x,x+4)y+1 + 3/5P(x,x+4)y+2 + 2/5P(x,x+4)y+3 + 1/5P(x,x+4)y+4$$

giving 25 person years of risk

Much of the analysis involved the same simple summary descriptive measures (SMRs, CMFs) described above. Further analyses involved log-linear modelling of the cohort death rates: details are given in Appendix 6.

3. RESULTS

3.1 Population at Risk

The age–sex distributions of the populations at risk were examined, as an aid to planning the analyses of mortality, and to interpreting the results. Attention was focussed in particular on how the distributions changed over time, and how these patterns varied between shale activity areas.

Some of the changes since 1911 are shown in Figures 3.1 to 3.7.

3.1.1 1911–1931

In 1911 the population at risk of all groups other than 'no shale rural' showed the pyramidical age sex distribution typical of high fertility and relatively high mortality. Between 1911 and 1931 this shape changed to one which was undercut at the base and thickened out at the top, indicating a fall in fertility (which was very late compared with the rest of the country: Newell, 1986) and a fall in mortality at middle and older ages. The decline in fertility had begun earlier in the 'no shale rural' population, giving by 1911 an age sex distribution which was already undercut at the base, in contrast at that time to the industrial groups studied.

The Figures show two patterns suggesting that migration may have been an important influence in some age groups. Out-migration of young women in the age groups 15–24 was particularly pronounced in the 'high shale' and 'no shale industrial' civil parishes in 1911, and persisted right up until 1931. The reverse was true in 'no shale rural' with a slight excess of females in these age groups. Secondly, by 1921 the effect of the First World War was obvious in all the populations, with the proportion of men aged 15–34 much less than in 1911. By 1931 this small age group reached expected proportions again in the 'high shale' area. Recovery was slightly less in the other areas; for example, by 1931 there were fewer men aged 35–39 than aged 40–44 in the 'low shale' and 'no shale rural' populations. These patterns suggest that migration occurred between the various shale activity areas, at least for some segments of the population, a view supported by information from the interviews.

3.1.2 1953–1981

Detailed cancer-specific mortality data are available from 1953. By then, all the population distributions were a similar shape. Mostly, they reflect changes in fertility: age groups of those born in the 1920s and 1930s were small, with a bulge at the bottom from the post war baby boom. The indentation for males in the 15–24 age group is almost certainly due to National Service: Forces population, and mortality, were recorded separately from all other groups.

By 1971 however differences between the three populations were once again apparent. The shale area had reverted to a pyramidical population, principally because the construction of Livingston New Town had attracted in young couples, and swelled both the 25–34 and youngest age groups, though by 1981 the distributions in all three areas were once again undercut at the base. However, the populations of all the shale activity areas populations were substantially younger than that of Scotland as a whole, the effect being most pronounced in the shale area, and most likely attributable, as discussed above, to in-migration to Livingston New Town.

3.1.3 Implications for the Analysis

These results confirmed that, as expected, analyses of mortality should be standardised for age, because of substantial differences in age distributions over both space and time. The implications of in-migration on interpretation of the results are considered in the Discussion.

3.2 All-Cause Mortality 1911-31

3.2.1 Differences between Shale Activity Areas

An initial analysis (of directly standardised death rates, using as standard the 1921 shale study area population, both sexes combined) showed little difference in overall mortality levels between the 'high shale', 'low shale' and 'no shale industrial' activity areas, whereas the 'no shale rural' area had much lower overall mortality throughout the whole period (Figure 3.8).

Life table analyses confirmed and refined this finding. The measures of life expectancy $\overset{o}{e}_0$ and $\overset{o}{e}_{15}$ (Section 2.6.2), in original units (Table 3.1) or standardised relative to a sex-specific baseline of 1911-15 in the 'high shale' area (Table 3.2), show clearly that for both sexes, life expectancy in the 'no shale rural' area was higher than in any of the industrial zones. The differences in $\overset{o}{e}_{15}$ are however smaller than in $\overset{o}{e}_0$ suggesting that mortality differences in the first 15 years of life are an important component of the overall differences between rural and industrial areas. Differences between the three industrial areas were small throughout, both for women and for men, with a suggestion that in the latest period, 1926-30, life expectancy was higher in the two shale areas than in 'no shale industrial'.

Any detrimental effect of working and living in the shale areas may have strongest influence on mortality at ages 15-64 and 15-74, i.e. among people of working age. Analyses of the probability of dying at these ages confirmed the two main previous findings: the probability of dying was clearly lowest in the 'no shale rural' area, whereas the other three zones showed little difference from one another (Tables 3.3, 3.4). In addition, it appeared that the gap between the rural and industrial areas increased with the passage of time, both for men and for women.

Further analyses of crude death rates (for each shale activity area, over 10-year age-groups and 5-year calendar periods, separately for men and for women) using log-linear modelling, again substantiated the two main results (Table 3.5), and provided some new insights. For example, for both women and men, death rates in the 'no shale industrial' area were higher, in the older age groups only, than those in the 'shale' areas (Figures 3.9, 3.10): the difference was due to the more steeply increasing rates with age in the 'no shale industrial' area. (This age effect is also implicit in Table 3.5 where the rates for 'no shale industrial' are significantly higher than those for 'shale' when all ages are included in the analysis, but not for analyses restricted to the subgroup aged 15-74.)

Similarly, for females only, the differences between the 'no shale rural' area and the other areas increase at older ages (Figure 3.11, 3.12).

In addition, results from the log-linear analysis indicate that, for males, the contrast between the death rates in the 'no shale rural' area and elsewhere depended to some extent on calendar period, with the contrast between the areas becoming much reduced during the years 1916-20, and to a lesser extent during 1921-25 (Figure 3.11). There was no corresponding time-dependence for females.

3.2.2 Comparisons with Mortality in Scotland

Log-linear analyses of crude (age-, year- and sex-specific) death rates also showed that men in all shale activity areas had significantly lower than men in all Scotland, at ages 15-74; the same result held for males over all ages (Table 3.6). These differences were less marked in the older age groups (at age 65 or more).

Women in the 'no shale rural' area also experienced lower mortality than in Scotland as a whole, but the experience of women of working age (i.e. 15-74) in the industrial areas was scarcely better than that of women in Scotland generally (Table 3.6). These results are again dependent on age, and when all ages are included, the mortality of females in both the 'shale' and 'no shale rural' areas was significantly less than that of females in all Scotland.

3.2.3 Comparisons: Men and Women

The mortality of men in the study area was less than other men in Scotland, whereas it was not clear that women in the study area were favoured similarly relative to other Scottish women. Nevertheless, the sex-specific standardised death rates show that, in general, male mortality was higher than female. In the 'high shale' area the difference was less marked than elsewhere, until the later 1920s.

These patterns are illustrated in Table 3.7 (using values derived from Table 3.3), where it can be seen that the ratio of male to female probability of dying at ages 15-64 or 15-74 was in general greater than one. The effect was clear in the 'no shale rural' area throughout, apart from an unexplained drop in the years 1921-25. Elsewhere, female mortality was higher or equivalent to male in 1911-15 and remained so in the 'high shale' area until after 1925. However, in all four areas, the ratio of male to female adult mortality increased throughout the two decades of the study, leading to the overall pattern of generally higher male death rates.

Investigations into mortality levels during reproductive years (15-44) showed that mortality differences between the sexes were more marked at these ages with women having the greater mortality: this is quite likely to be due to high levels of maternal mortality earlier on.

3.2.4 Other Points of Interest

There were several other points of interest in the Tables and Figures discussed above. For example, in the directly standardised death rates of Figure 3.8, a synchronised mortality peak occurring in all the areas in 1918 was due to the 'flu epidemic; and there was a mortality peak in the two shale areas in 1915, which we are unable to explain. Otherwise, industrial events that might be postulated to raise mortality, such as the 1921 lock out, the 1925-6 strike in the shale industry, and the 1926 coal strike, did not correspond with mortality peaks. The most noticeable trend in Figure 3.8 is for substantial fluctuations in the first decade under study, and then a gradual lowering of mortality throughout the 1920s.

It was also interesting to note that in all the areas studied, the measures of life expectancy rose quite rapidly over the two decades 1911-31, for both men and women (Tables 3.1, 3.2). That the $\mathring{e}_{15}$ rose much less rapidly than $\mathring{e}_{0}$ indicates that most of the mortality improvements occurred in childhood. This is presumably related to the falls in fertility, better maternal and child health facilities, and general medical care; it is certainly not unique to these areas but was occurring simultaneously over all of the British

Isles.

For mortality at all ages, and for adults in particular, the big jump was around 1920. In a way this is curious because the 1920s saw the onset of the most poverty in the area, with the pre- and post-war boom finished, employment less secure and wages reduced: health as reflected in mortality levels was clearly dominated by factors other than the purely economic. The jump in the ratios around 1920 is even more marked in Table 3.3 (showing the probability of dying at ages 15–64 or 15–74) than it was in the all ages mortality (Tables 3.1, 3.2), although adult mortality fell rapidly throughout the whole two decades.

3.3 Aggregate (All–Cause) Mortality, 1963(53)–81

Three measures of aggregate mortality were considered: death rates from all causes 1963–81, death rates from all non-malignant causes over the same period, and death rates from all cancers over the longer period 1953–81.

3.3.1 All–Cause Mortality, 1963–81

As in the earlier period 1911–31, all–cause mortality 1963–81 was much lower in the 'no shale rural' area than elsewhere, for both males and females (Figure 3.14). And as before, there were no substantial differences in female mortality between other areas, over the whole time period. However male mortality in the 'shale' area was much higher than in the 'no shale industrial' area until the early 1970s, after which there was little difference.

For both sexes, overall mortality in the shale area was higher than that of Fife, Borders and Midlothian for most of the time, in particular for the earlier part of the period (Figure 3.13). Figure 3.14 shows that this excess existed at ages 15–74, and so was not just a function of high death rates in the smaller old age groups. After 1968, male adult (i.e. at ages 15–74) mortality levels in the shale area were the same as those in 'no shale industrial', and similar to those in Fife and Midlothian. Mortality of women aged 15–74 was slightly higher also in the earlier years, both in the shale and the 'no shale industrial' areas.

Logistic regression analyses confirmed that, for both sexes, all–cause mortality in the shale area was consistently worse than that in Fife, at all ages and in the subgroup of adults aged 15–74 (Table 3.8). Corresponding risks relative to all Scotland, and to the 'no shale industrial' area of the study, also tended to be marginally higher than unity, but the estimated excesses were not statistically significant.

As indicated above, these patterns were to some extent dependent on time period or on age. For example, the estimated risk of all–cause mortality among males at all ages was elevated in the shale area relative to the 'no shale industrial' area (Table 3.8), a difference which was most pronounced during the period 1963–67 (Figure 3.14). Also, the risks of female mortality in the shale areas relative to all Scotland were not entirely consistent over age–groups: Table 3.8 points to some discrepancies between results for all ages, and at ages 15–74. Regression analyses did not indicate that these age differences depended on time period.

3.3.2 Mortality from Non-malignant Causes, 1963-81, and from all Cancers, 1953-81

Non-malignant causes, as a group, accounted for most deaths; and patterns of mortality from non-malignant causes therefore mirrored those of all-cause mortality throughout the period. For example, Table 3.8 shows a slightly elevated and statistically significant relative risk of about 1.07 in the shale area relative to mortality in Fife, for both women and men. Males in the shale area had higher risk of mortality from non-malignant causes relative to males in the 'no shale industrial' area, but this was not so for women: at working ages 15-74, the tendency was in the opposite direction.

Cancer mortality among those in the shale area, compared with Fife, also reflected the overall picture, with some excess risk in all comparisons (Table 3.8). The cancer excess, though similar in magnitude to that from all causes and from non-malignant causes, was not statistically significant however, reflecting presumably the smaller numbers of cancer deaths compared with deaths from other causes.

Other patterns of cancer mortality differed for males and females. Among men, the standardised death rates for all cancers showed a general rising trend throughout the period, in all the shale activity areas as well as the comparison areas (Figure 3.15). Figure 3.15 indicates that male mortality from cancers was high in the shale area compared with 'no shale industrial' and 'no shale rural', particularly in the same years that the all-cause mortality was high, that is 1963-69. This suggests that some at least of the all-cause peak might be due to cancer. Table 3.8 gives some supportive evidence, not statistically significant, and weaker at ages 15-74 than at all ages, that cancer risks among males were slightly elevated in the shale area relative to 'no shale industrial'. There was no evidence that risks of cancer in the shale activity area were higher than in Scotland as a whole (Table 3.8), where results are strongly influenced by mortality in the Clydeside conurbation (Kemp *et al*).

In contrast to the men, standardised death rates from all cancers among women showed no evidence of an increase over time, and no clear evidence of differences between areas (Figure 3.16); and logistic regression comparisons of female cancer mortality in the shale area relative to all Scotland, or to 'no shale industrial', gave no evidence of any large or statistically significant contrasts (Table 3.8). Relative to 'no shale industrial', the estimated risk of cancer mortality among women in the shale area was however slightly elevated. This was in contrast to female mortality from non-malignant causes, but was nevertheless less than the corresponding estimated relative risk for male cancer mortality.

3.4 Cause-specific Non-malignant Mortality 1963-81

Table 3.9 shows the numbers of deaths 1963-81 in the shale area and in selected comparison areas, from 18 distinct groups of non-malignant causes, separately for males and for females. The majority of deaths were due to ischaemic heart disease (IHD) and cerebrovascular disease, with IHD clearly the major cause of death among men.

SMRs by cause, sex and period for the shale area relative to all Scotland are given for males and females in Table 3.10, and the corresponding data for 'no shale industrial' in Table 3.11. In addition, Tables 3.12 to 3.14 summarise the results from the log-linear analysis in the form of estimated risks in the shale area relative to those in all Scotland, in Fife and in the 'no shale industrial' area respectively.

The following comments highlight, by cause of death, those results where differences were seen or suggested.

3.4.1 Ischaemic Heart Disease

There is consistent evidence that age-standardised death rates from ischaemic heart disease among males were higher in the shale area than in any of the comparison areas. The IHD SMRs for men in the shale activity area ranged between 100 and 110 over the four time periods (Table 3.10), whereas corresponding SMRs for men in the 'no shale industrial' area all lay between 90 and 99 (Table 3.11). Direct comparisons, using log-linear methods, confirmed this finding, with IHD risks for men in the shale area relative to those in Scotland, Fife and in the 'no shale industrial' area estimated as 1.05, 1.06 and 1.12 respectively (Tables 3.12 to 3.14). Comparisons with Scotland and Fife were (just) statistically significant at the 5% level; that between shale and 'no shale industrial' men was more clearly significant statistically.

There was no evidence of a corresponding excess from IHD among females in the shale activity area.

3.4.2 Cerebrovascular Disease

SMRs (Table 3.10) and associated relative risks (Table 3.12) from cerebrovascular disease were raised among women in the 'shale' activity area relative to all Scotland. However, SMRs from this cause among women in the 'no shale industrial' area were also high (Table 3.11); and direct comparisons of relative risks in these two activity areas did not point to real differences (Table 3.14).

Corresponding SMRs for men in the shale area were high relative to Scotland during 1963-67 (Table 3.10), but over the entire period 1963-81 the risks were again similar to those in the 'no shale industrial' area.

3.4.3 'Other Circulatory Diseases'

Table 3.10 also shows that SMRs from 'other circulatory diseases', (i.e. circulatory disease excluding IHD and cerebrovascular disease) among men in the shale area also varied irregularly over time, but tended overall to be elevated. Estimates of relative risks 1963-81 indicated that the excess was real relative to Fife (Table 3.13), and possibly so relative to all Scotland (Table 3.12). There was no evidence of correspondingly elevated SMRs among men in the 'no shale industrial' area (Table 3.11), and so the direct contrast of shale with 'no shale industrial' men gave a statistically significant, elevated relative risk of 1.15 (Table 3.15).

The pattern among women in the shale area was similar, though SMRs were not subject to the same variations over time (Table 3.10). Estimates of risk relative to Scotland, Fife and 'no shale industrial' ranged between 1.11 and 1.15, and were generally significant at the 5% level.

3.4.4 Industrial Lung Disease

The vast majority of diseases classified as 'industrial' are linked with coalmining; results are given for men only.

Analyses of mortality from industrial diseases among men in the shale area are based on 25 deaths only (Table 3.9). Nevertheless, the SMRs and relative risks were raised substantially and significantly compared with all Scotland; for example the relative risk was estimated as 1.51 (Table 3.12). Comparisons with Midlothian (not shown) and with

Fife (Table 3.13) suggested respectively a reduced excess, and a relative risk of 0.85, reflecting the greater proportions of the male populations of these areas involved in coalmining.

It is scarcely surprising then that for men in the primarily coalmining 'no shale industrial' area, the SMR from industrial lung disease was about 450 relative to all Scotland for most of the period (Table 3.11). Relative to this baseline, risks among men in the shale area were very low (estimate 0.35: Table 3.14).

3.4.5 Bronchitis and Emphysema

Among non-malignant causes, bronchitis and emphysema had been of particular interest as a possible cause of excess mortality in the shale area. Results showed however that SMRs were not elevated relative to all Scotland either for men or for women (Table 3.10), nor were the corresponding relative risks (Table 3.12). There was however evidence of an excess relative to Fife among women, estimated as a relative risk of 1.25, and just significant statistically (Table 3.13). Risks were marginally elevated also relative to 'no shale industrial', but not at all statistically significant (Table 3.14); and interpretation is in any case difficult because of the clear increase in SMRs over time among both women and men in the 'no shale industrial' area.

3.4.6 Other Respiratory Disease

The relative risks of mortality from 'other respiratory disease' were elevated for both males and females in the shale area compared to Fife (Table 3.13). There was no evidence of an excess relative to 'no shale industrial' (Table 3.14), and comparisons with Scotland were inconclusive (Tables 3.10, 3.12). Interpretation is in any case difficult because the predominant cause of death in this group was pneumonia, and doctors may vary widely in their attribution of pneumonia as a primary cause of death.

3.4.7 Musculo-skeletal

SMRs for mortality from musculo-skeletal causes were high relative to all Scotland among men (Table 3.10) but, being based on only 13 deaths in the shale area (Table 3.9) they fluctuated with time-period. Corresponding SMRs among men in 'no shale industrial' were low (Table 3.11).

Log-linear analyses suggested that the risk relative to all Scotland was substantial (estimate 1.5) but not statistically significant (Table 3.12), with a lower estimate relative to Fife (Table 3.13). The large excess of 2.45 relative to 'no shale industrial', statistically significant at the 5% level, was (as indicated above) due in part to low death rates in the coalmining area.

3.4.8 Benign Neoplasms

Suggestions of an increased risk among men in the shale area relative to Scotland (Tables 3.10, 3.12) and Fife (Table 3.13), and based on only 10 deaths (Table 3.9), were not supported by direct comparison with the 'no shale industrial' area (Table 3.14).

3.4.9 Psychoses

Mortality from psychoses was another non-malignant cause where excess deaths in the shale area were suggested by the results. Risks among men were high relative to all three comparison groups reported here (Tables 3.12 to 3.14), ranging from 1.85 to 2.49, and in general significant statistically. Corresponding relative risks among women were lower but were also elevated, at about 1.5; and statistical significance was less clearcut (Tables 3.12 to 3.14). SMRs were consistent with these findings (Table 3.10). Once again, however, the numbers of deaths in the shale area were small, at 19 and 23 for men and women respectively; and the vast majority were senile dementia among people aged 80 years or more.

3.4.10 Endocrine and Metabolic System

There was some evidence in both the SMR and log-linear analyses of an excess in deaths from diseases of the endocrine and metabolic system for females compared to Scotland (Tables 3.10, 3.12) and to Fife (Table 3.13), the SMR analysis showing that the excess deaths all occurred in the later part of the period. SMRs among females in the 'no shale industrial' area were also high (Table 3.11), and though the pattern was more consistent over time, the excess was again greatest later in the period. Direct comparisons suggested that the risks among women were lower in the shale than in the 'no shale industrial' area.

3.4.11 Other Non-malignant Causes

Deaths from 'other internal causes' (mainly neonatal and infant deaths) were also raised in the shale area compared to Fife, for females.

There was consistently low mortality for both sexes from diseases of the nervous system and sense organs in the shale area, whereas the SMRs in the other activity areas fluctuated around the same level as Scotland; results for 'no shale industrial' are in Table 3.11.

3.5 Cause-Specific Cancer Mortality 1953-81

The total numbers of deaths from the 16 cancer causes in the shale and comparison areas are given in Table 3.15. Respiratory was clearly the major malignant cause of death among males, with 508 deaths from respiratory cancer comprising almost 40% of all male cancer mortality. No single cause predominated to the same extent among women: breast cancer, with 203 deaths, was the most common malignant cause, but accounted for only 20% of all female cancer deaths. These results broadly reflect the patterns of crude death rates in the comparison areas also (Table 3.15).

Cause-specific SMRs, standardised relative to all Scotland, are reported by sex and for each of six time periods, for the shale and the 'no shale industrial' activity areas, in Tables 3.16 and 3.17 respectively. Estimates of relative risks for the shale area compared to Scotland, Fife and 'no shale industrial' are given for males and females in Tables 3.18 to 3.20 respectively.

The main results are summarised below, by cause of death.

3.5.1 Cancer of the Stomach, Large Intestine, Rectum.

There was no consistent evidence of excess mortality in the shale area from cancer of any of these three sites.

SMRs and relative risks from stomach cancer were generally less than in the comparison areas, for both men and women.

SMRs and relative risks of cancer of the large intestine were also low relative to Scotland (Tables 3.16, 3.18), but slightly elevated relative to Fife (Table 3.19). A slight excess among men relative to 'no shale industrial' (Table 3.20) was due in part to low death rates from this cause among men in the industrial area, in the later part of the period (Table 3.17).

Mortality from malignant neoplasms of the rectum was also low in the shale area, particularly for women. (Both sets of SMRs suggest a trend with time, but in opposing directions: Table 3.16.) Relative risks among women were about 0.6 in all three comparisons and, though based on only 27 deaths, this deficit was statistically significant.

3.5.2 Cancer of the Liver

Results are based on only six deaths each among men and among women (Table 3.15); contrasts vary in magnitude, and are not consistently high or low across comparison areas; none of the estimated relative risks is statistically significant.

3.5.3 Cancer of other Digestive Organs

SMRs (relative to all Scotland) and log-linear estimates of risks relative to Scotland and to Fife were elevated both for men and for women in the shale activity area. Relative risks were estimated in the region 1.1 to 1.2, the comparisons with Fife approximating statistical significance at the 5% level (Table 3.19).

SMRs from other digestive cancers were however also somewhat in excess of 100 for both men and women in the 'no shale industrial' area (Table 3.17); and direct comparisons suggested that over the time-period as a whole, the age-standardised risks for both sexes were similar in the two areas (Table 3.20).

3.5.4 Respiratory Cancer

Comparisons with Scotland gave no evidence of excess mortality from respiratory cancer, for men or for women in the shale activity area (Tables 3.16, 3.18); indeed, SMRs for women were quite low in the middle years of the study period. However, SMRs for men and women in the 'no shale industrial' group were also low relative to Scotland as a whole (Table 3.17), and relative risks in the shale area were estimated as slightly elevated in comparisons with 'no shale industrial' and with Fife. The estimates of 1.08 and 1.09 respectively for men were not statistically significant at the conventional 5% level, but were at slightly higher probability levels. Relative risks of similar magnitudes were estimated for women, but were based on fewer deaths, and were not statistically significant.

3.5.5 Skin Cancer

Results are based on nine deaths among men, and five among women, in the shale activity area (Table 3.15). Estimates of risk relative to Scotland and to Fife gave values in the region 1.15 to 1.35 for both sexes; these estimates were subject to wide random variability. Comparisons with 'no shale industrial' were more extreme, with relative risks estimated at 1.7 and 1.9 for men and women respectively; but the very wide confidence intervals associated with these point estimates show that chance variations may have had an important influence on the estimates.

3.5.6 Bladder and Kidney Cancer

A substantial and statistically significant excess in the number of deaths from bladder cancer was seen for women in the shale area compared to both Scotland (relative risk 1.57) and Fife (relative risk 1.77). The estimated relative risk for bladder cancer compared to 'no shale industrial' was similarly high, at 1.53, but was not statistically significant at the 5% level. Results were based on only 33 deaths in the entire period 1953–81, and so SMRs by time-period showed some irregularities, varying from 68 to 273 (Table 3.16). The overall pattern of SMRs however did point to the excess confirmed by the relative risk analyses, and showed no obvious trend with time.

Estimates of relative risks in the shale area from bladder cancer among men, and from kidney cancer among men and among women, were within the range 1.0 and 1.3 according to comparison area, the highest being the risk of kidney cancer among men relative to Fife and to all Scotland. None of these excesses was statistically significant however; nor was the risk of male kidney cancer particularly high in shale relative to 'no shale industrial' (Table 3.20).

3.5.7 Other Genito-urinary Cancer

The SMRs (compared to all Scotland) for 'other genito-urinary cancer' (i.e. excluding bladder and kidney) were generally high among men in the shale area (Table 3.16), whereas corresponding SMRs among men in 'no shale industrial' were generally less than 100 (Table 3.17). Estimates of risk relative to all Scotland and to Fife were 1.19 and 1.16 respectively, the comparison with Scotland being close to significance at the 5% level. As expected from the SMRs, risk relative to 'no shale industrial' was higher, at 1.55 (95% CI 1.18, 2.05), and was significant statistically.

There was no evidence of excess mortality from this cause among females.

3.5.8 'Other' Cancers/Cancers of Unknown Site

Estimates of relative risk for both women and men were greater than unity in all comparisons made (Tables 3.18 to 3.20). In particular, risks in women relative to Scotland and to Fife were estimated at about 1.25, at about the 5% significance level.

3.6 Cohort Analysis

The data available for analysis by birth cohort differed according to cause of death and period in which the deaths occurred. For deaths from cancers, each cohort had five rates from adjacent time periods during 1953–81; for non-cancer deaths, rates from three periods only were available spanning 1963–81. (In principle, all-cause data from the earlier period 1911–31 were also available, but are not reported here.)

With so few rates per cohort, it is obviously not easy to separate cohort from period effects. No attempt was therefore made to study causes where numbers of deaths were few; but even with this restriction, comparisons between birth cohorts in the same areas must be viewed with caution.

The groupings of causes which were investigated were:

1. all causes
2. all cancers
3. lung cancer
4. bladder cancer
5. other genito-urinary cancer
6. ischaemic heart disease
7. cerebrovascular disease

The calculated rates are given in Appendix 6, by age and period of death, for both sexes separately, in the three defined shale activity areas; together with a schematic demonstration of the relationship the individual cohorts bear to the age groups and pivotal years of death. The very low rates for age groups under 40 are omitted.

Choice of standards for the summary statistics can be problematic for comparisons between cohorts within areas. For CMFs, where the principal use of the standard is provision of an age distribution, a combined standard of all areas, all cohorts and both sexes was created. This was intended to represent the average mortality experience of the whole area for 1963 to 1981. For SMRs, two different standards were used: rates for all Scotland in 1971, because the larger numbers gave more stable rates; and a combination of the three areas and all cohorts, used as an indication of the general mortality experienced in the area.

An environmental hazard would be expected to operate on both sexes, and should be detectable as a cohort effect, if its effects changed with time. If it operated only on one sex, it would be unlikely to be an environmental effect.

These considerations influenced the interpretation of results which, because of the generally negative findings, are simply summarised briefly here in the text. For example, none of the tables of cohort CMFs or SMRs indicated any cohort-related trend in mortality which might be related to changing levels of shale activity in the area. Although all the 'no shale rural' cohorts exhibit lower mortality than the cohorts in the other two areas, this differential was apparent throughout the period covered by the deaths, and is thus not likely to be interpretable as a cohort effect. Nor did log-linear analyses of the death rates, as described in Appendix 6, give any evidence of an environmental hazard in the shale area. (The strongest cohort effect was noted in respiratory cancer in males, but this was interpreted as reflecting the known strong trend during this century in rates for this cause, believed to be due to changing smoking habits.)

3.7 Further Analyses of Mortality from Cancers of Particular Sites: A Case-control Study

3.7.1 Background, Design and Subjects

The cause-specific analyses of cancer mortality 1953–81 had suggested that in the 'shale' area (relative to 'no shale industrial'), women were at excess risk of bladder cancer and men at excess risk of 'other genito-urinary' cancer (Section 3.6; Tables 3.18 – 3.20) . Some information additional to that analysed in Section 3.6 was available, but only for people who had died. These data were used in further analyses in order to explain better, if possible, the reasons for the apparent excess risks. Mortality from skin cancer was also included in this further study because of its known association with the shale industry; estimates of relative risk in Section 3.6.5, though subject to very large chance variations, had been consistently greater than unity for men and for women in the shale activity area.

A case-control approach was adopted. Cases and controls were selected from those residents of the entire shale study area (i.e. the 'shale', 'no shale industrial' and 'no shale rural' activity areas combined) who had died 1953–81. The cases were defined as all (74) females who had died from bladder cancer, all (255) males who had died from 'other genito-urinary' cancer, and all (21 male, 13 female) who had died from skin cancer. All (3565 males, 2885 females) who had died from cancer other than at the three sites of interest were included as controls. Thus, for example, women who had died from 'other genito-urinary' cancers were not included either as cases or controls.

3.7.2 Data and Methods

The data available for case-control comparisons consisted of year of death, age at death, civil parish of residence at death and (for men) occupation at death, which was coded according to the revision of the 'coding of occupation' current in the year of death. (The occupation of unmarried women was coded for those who had been in paid work since leaving school, while married women were classified by their husband's occupation. However these data were incomplete and therefore not analysed.)

Different conventions had been used for coding occupation at death in the four periods 1953–58, 1959–69, 1970–79, and 1980–81; and each revision consisted of several hundred job codes. It was difficult to assess the relevance to the shale industry of these codes, because occupation at death was not necessarily indicative of a man's occupation throughout his working life. In particular, following the closure of the shale industry in 1962, many ex-shale workers would have been coded according to the job they held after they left the industry. Despite these difficulties, the occupational job codes were classified subjectively into four groups : coalmining, probable shale, possible shale and other (details in Appendix 7).

Civil parish of residence and occupation at death were of specific interest in the analysis because of possible links with areas or jobs exposed to shale. Possible interaction between these two factors was also considered. The distributions of year at death and age at death were also examined as possible confounding factors. The data were examined first in a series of descriptive two-way tables and subsequently, logistic regression was used to investigate further the associations suggested by the tabular analysis.

3.7.3 Results

On average, cases from the three causes of interest had lived longer than controls (Table 3.21), and in men and women, deaths from skin cancer tended to occur earlier in the study period (between 1953–59) than deaths from other cancers (Table 3.22).

There were differences in the distribution of cases and controls to shale activity area (Table 3.23). This was to be expected as a simple consequence of the design, and should not be considered a new finding. (The causes of death under study by case-control methods were precisely those where excess mortality in the shale activity area had been indicated in earlier results; and the cases in the present analyses were exactly the same people whose deaths had suggested an excess mortality from these causes in the shale areas, in the first instance: see Tables 3.15 and 3.23.)

New information from the case-control study was available in respect of the distribution of cases and controls by civil parish and (among men) by occupation at death. The data were therefore further classified by civil parish within activity area but it was difficult to interpret the information because numbers of cases per civil parish were in general small (Table 3.26). For example, among men the greatest excess of 'other genito-urinary' cancer occured in the 'shale' area parish of West Calder, but the overall differences in distribution of 'other genito-urinary' cases and controls to the six civil parishes in the 'shale' area were not statistically significant.

Among women, analysis by civil parish pointed again to West Calder, and Uphall, as the civil parishes with greatest excess of bladder cancer (Table 3.26); but as noted above for men, it is difficult to judge whether this is a real or chance pattern, because of small numbers of cases.

Table 3.27 gives numbers and percentages of male cases and controls in each of the four occupational groups. During the earlier years, 1953-69, there were proportionately more deaths from both skin cancer and other genito-urinary cancer among 'probable shale' workers than in the other occupational groups. However, the pattern for skin cancer may reflect chance variations because of the small number of deaths in each group.

As a consequence of the design, and as noted in Table 3.25 above, residence in the 'shale' area was also positively associated with being a case, and so the analysis by occupation was repeated, but limited only to the 'shale' activity area, to see if the apparent association with 'probable shale' work simply reflected a residence effect. It did not: 19 (33%) of the 57 male cases of other genito-urinary cancer in the 'shale' area 1953-69 had worked in 'probable shale' occupations, compared with 107 (19%) of the 551 controls, and three of five cases who died from skin cancer.

This finding was supported by logistic regression analysis, where the probability of death from 'other genito-urinary' cancer was examined in relation to age, year, occupation (in the four broad categories defined above) and shale activity area. Comparisons were with male controls, over the whole time period 1953-81 and for deaths in the early years 1953-69 only (where Table 3.27 had most clearly shown an effect of occupation, and for which the occupation in the shale industry is most likely to be accurate).

The results showed the expected association between the probability of dying from 'other genito-urinary' cancer and residence in the 'shale' area (Table 3.28). This probability of being a case was lower in both the 'no shale rural' and 'no shale industrial' areas compared to 'shale', significantly so in the case of 'no shale industrial'. The association was much stronger in the period 1953-69 than 1953-81.

Analysis of occupation rather than area showed no significant relationship between dying from other genito-urinary cancer and occupation at death in either time period. However, after adjustment for area, the logistic analyses indicated that in the earlier period, 1953-69, the risk of being a case rather than a control was elevated among men in 'probable shale' jobs relative to 'coal' and 'non-shale' occupations at death, but the difference was not statistically significant.

4. DISCUSSION

4.1 Objectives and Plan of Work

The present study had two main objectives, both intended to complement the earlier investigations of mortality and morbidity among men employed 1950-1962 in the shale industry in The Lothians in Scotland. The first was to identify any patterns of increased (cause-specific) mortality among men employed when the industry was at its peak, but who had not been included in the earlier studies (either because they were employed by companies other than the dominant one of Scottish Oils, or because they had left employment in Scottish Oils before they could join that company's Provident Fund, instituted in the early 1950s). The second objective was to identify any adverse impact of the industry on the adjacent communities, and especially on groups not included or under-represented in the earlier studies: women of working age, and both the very young and the very old, of either sex.

The broad strategy of the study was to

(a) Identify those small areas where aspects of the shale industry (mining and processing) were an important activity, and nearby small areas where there was little or no shale activity but which were, hopefully, similar to the shale activity areas in other respects. In practice, it was necessary to distinguish between industrial and rural non-shale areas.

(b) Compare and contrast cause-specific mortality in these various shale activity areas, and interpret the results in relation to the objectives.

4.2 Methodological Difficulties and their Implications

Several methodological difficulties were encountered in the course of the study. Some of these were resolved well, others only partially, others not at all; it is useful to review them briefly, before seeking to interpret the substantive results of the study.

4.2.1 Reliability of Population and Mortality Data

Obviously the validity of all the analyses done is dependent on the completeness and accuracy of the population and death data available. In the descriptions (Section 2) of the adjustments made to the data in order to reduce the possibility of biases most of the relevant issues have been touched on.

(a) Completeness of tracing

In particular, for the 1911-31 data the extractions from the registers did not locate all the deaths, though high percentages of tracing were achieved. The checks against published statistics indicated that tracing was most complete for the no shale rural area; thus using the crude figures one would expect higher mortality to be shown there. In fact the results showed that area to have consistently the lowest overall mortality. Combined with the probable levels of omitted data this suggests that the mortality differences between no shale rural and the other areas were in reality even more marked than demonstrated. The checks gave no reason to believe that any of the other areas were subject to differential levels of tracing. Obviously statistical comparisons with published figures required that corrections be made for the level of omitted deaths. These were done and so the comparisons with Scotland reflect genuinely lower mortality in the shale areas rather than an artefact of the data collection methods.

The data used for 1953–81 may be assumed to be complete, as they are the nationally collected registrations of all deaths.

(b) Attribution of deaths 1911–31 to shale activity area

The problem, noted earlier (Section 2.6.1), was that until 1966 all deaths in Scotland were registered in the registration district (RD) where the death occurred, whereas for the present study it was necessary to identify all individuals who died in a risk population defined by RD of usual residence. Deaths in hospital were the major reason for the difference. The difficulty was tackled by a suitably intensive search of registers of RD's which contained the major hospitals serving the shale study area (Section 2.6.1); and it was possible to verify that this approach was successful (Appendix 4). There is no reason to consider that the distribution to RD of the few deaths still unaccounted for was biassed either for or against the 'shale' areas.

(c) Coding of cause of death

The quality of the coded causes of death may not always be consistent. However, when using nationally collected and coded data to compare different areas for the same time periods these inconsistencies are not always important because particular biases and errors may cancel each other out. For example the change in the Scottish death certificate in 1964 (Annual Report, 1964) led to changes in the frequency of different 'underlying cause of death' but as this applied to both the study and comparison populations it should not lead to biassed results.

More important is the small size of the shale area and its dependence since the second world war on a single general hospital. A large proportion of deaths will have been certified by few doctors whose personal characteristics and idiosyncrasies could have influencd the recorded cause-specific patterns of mortality. Cochrane and Moore (1981) identified problems of 'lazy' doctors who just recorded one cause of death; Bloor, Samphier and Prior's (1987) review of artefactual effects on mortality data mention other characteristics of doctors likely to influence mortality statistics where only a few certifiers are concerned: age of practitioner (Diehl Gau, 1982) and place of training are two relevant factors. The internal comparisons should largely avoid these problems – particularly comparisons between the shale and no shale industrial areas – because the same hospital serves the majority of the whole shale study area. The external comparisons on the other hand are subject to these problems to an unknown extent.

(d) The populations at risk

The quality of the population at risk data was discussed above (2.4): the linear interpolations do not produce systematic biases in the age distributions of the populations and without detailed civil parish level birth and migration data no greater accuracy could be achieved.

4.2.2 Differences between Shale Activity Areas in respect of Shale Activity

Sufficient background information was available about the shale industry (Appendix 1) and other industrial activities in the study area (Appendix 2) to enable reliable groupings to be formed of Civil Parishes, distinguishing between 'shale', 'no shale industrial' (or 'coal'), and 'no shale rural', based on level of shale activity at the time (1911–31), or 20 years earlier (for deaths 1953–81).

The key issue methodologically then is how appropriate, given the objectives of the work, is a grouping of Civil Parishes by intensity of shale activity (unlagged or lagged). The most likely routes of any health effects are either direct or indirect contact with the material or its by-products (i.e. through work activity, atmospheric pollution, or other contact in daily life), or through lifestyle factors affected by the presence of shale or other industries. Lifestyle and related factors are considered further below (Section 4.2.4). With regard to direct or indirect exposure, it seems reasonable to consider that a grouping by shale activity is a good indicator of atmospheric pollution, and a reasonable indicator of exposure at work: in these communities, there was a broad correlation between residence of shale (or coal) workers, and location of shale (or coal) activities.

4.2.3 Migration in and out of the Shale Study Area

(i) Out-migration

Migration was probably the major unaccounted for influence on the shale populations. Appendix 8 documents the estimated amount of net out-migration from the area in the 1911-31 period. This, complemented by information from the interview study (Randall, 1990; Chapter 8) suggests that out-migration was quite a major force in the area, at least until the 1960s. This is unlikely to have affected the mortality analysis to an important degree unless the out-migration was either closely related to health status, or to exposure to shale hazards; no evidence is available to test this. Unfortunately the data on residence recorded for the Provident Fund Study are not consistent enough to be able to measure levels of out-migration for those men; some records had the address updated and some did not. Also many men in the Provident Fund Study lived and worked in Grangemouth for all their working lives; these men cannot be separated from those originating from the shale industry area. We do know that 159 out of the original 6359 PF members (2.5%) had emigrated from the UK by 1981 and could not be traced.

(ii) In-migration

After the mid 1960s however in-migration became more important, as demonstrated by the population pyramids. Changing industrial patterns, the construction of new light industries in the area and development of private housing led a considerable number of people to move into the area which became more and more a commuter zone for Edinburgh.

We do not know if the in-migrants came from one area or one industry with a particular pattern of mortality, but there is no reason to suppose that they did. It is very unlikely therefore that excess mortality from any particular cause relative to Fife, Borders or Scotland as a whole was artefactually generated by in-migration. However, in-migrants to new light industries and to private housing may have experienced less severe age-specific mortality across all causes, and especially those related to lifestyle, than the longer-term residents. If so, any excesses typical of the study areas will have been diluted relative to elsewhere in Scotland; and patterns between the three shale areas will have been distorted insofar as in-migration occurred unevenly between them.

(iii) Livingston New Town

The possibility of distortion was most acute in respect of the development of Livingston New Town. This large scheme attracted a large number of (mainly young) families into the area. All the New Town area was in civil parishes defined as shale, and the boundaries encompassed some housing and one small village which definitely included many ex-shale workers. The effect of the New Town on the local population was substantial. In 1966, before construction started, the population within the New Town boundaries was 2415 (sample census 1966): by the 1981 census it was 36411. It is the New Town which largely dominates the age distribution shown for the shale area in 1981, with its very young population. Although it is possible to exclude both the population and deaths in the New Town area from the analyses, because local people also moved into the New Town this would also exclude many individuals who were exposed to shale. However, one of the policies in building the New Town was to rehouse people from slum areas around Glasgow and it is quite possible that their mortality patterns differed from those originally in the shale areas (see cancer map of Scotland).

Some analyses were redone excluding the Livingston New Town population from both denominators and numerators. It was found that this made little difference to the results and the conclusions that could be drawn from them and so all the results presented above include the whole area. Presumably the extremely young population of the New Town meant that, in fact, the in–migrants contributed little to the death rates. (By retaining the whole population in the analysis, the older people, who had been exposed to shale and continued to live within the New Town boundaries, were also included.)

The finding that results and conclusions were not sensitive to the inclusion or not of Livingston New Town does of course also provide assurance that other, less obvious, patterns of migration probably had little substantial bearing on the results.

4.2.4 Differences between Shale Activity Areas in Other Respects

(i) 'Shale' and 'No Shale Industrial'

For 1911–31, information from the interviews and censuses indicated that in terms of general life style, the 'no shale industrial' area was very similar to the 'shale' area, with the exception of the shale industry. Both had small populations in social classes 1 and 2, both were basically rural areas with small industrial towns and villages and similar levels of health care, with access to the same hospitals. This continues to be true for the comparisons between 'shale', and 'no shale industrial' in 1953–81, with the added similarity that the major extractive industry in each area was in decline in that period.

Other work on mortality patterns related to industry has been done in the area, concentrating on Armadale, one small town in a no shale industrial civil parish. Here (Lloyd, 1978) a very localised excess of lung cancer cases has been linked with pollution from an iron foundry, and during some of the period 1953–81 Armadale had extremely high mortality from lung cancer.

This excess need not affect the validity of 'no shale industrial' as a comparison area in the present study. Firstly Armadale is only a small portion of the no shale industrial population (1971 population = 7152). And secondly, although it was originally hypothesised that lung cancer might be related to work in the shale industry, the case control study done as a supplement to the Provident Fund studies indicated that lung cancer was not a hazard of working with shale (Miller *et al*, 1986).

Apart from migration, as discussed above, the existence of different major extractive industries (shale and coal mining) is thus the principal relevant difference between the shale and the 'no shale industrial' activity areas. Particular differences in the cause–specific mortality patterns may therefore be attributable, with caution, to the differential effects of these two industries.

(ii) 'No Shale Rural'

The 'no shale rural' area is rather more different from the shale area, in several respects. First, and as the name implies, there was little industry, which has implications both for the way of life and housing: for example there were no communities of miners' rows with cramped accommodation, as there were in the other activity areas.

Secondly, the 'no shale rural' area appears to be under a different demographic regime. The population distributions in 1911-31 show fertility falling earlier than in the other areas, and a greater proportion of older people. The standardised all-cause death rates were consistently lower than those of all the other three populations suggesting that differences were not just due to shale but also other factors.

Another factor which differentiates these 'no shale rural' civil parishes from the shale ones, particularly for the 1911-31 period, is that the area is dominated by civil parishes closer to Edinburgh, with the implications of access to a different health care system, a different labour market, and possibly more affluence. For example, an excess of young women in the 15-24 age groups indicates that it was an acceptor of domestic servants rather than a provider, suggesting a wealthier place.

From 1953-81 the 'no shale rural' area encompassed more civil parishes than in 1911-31, including three parishes that had been classified as low shale in the earlier period. Despite this reclassification, the 'no shale rural' area still has lower overall all-cause mortality for both sexes (but particularly for males - Figures 3.13 and 3.14) than both the other shale activity areas, Fife and Midlothian but similar levels to Borders, suggesting that it is the absence of heavy industry in general that is the dominant effect on mortality levels rather than the presence of any particular industry. This would automatically lead one to suspect that the cause-specific patterns of mortality would also differ, without being able to draw any conclusions about the relationship of these to shale production. The social class distribution, level of unemployment, provision of housing and housing tenure are all important determinants of mortality levels and could all be subsumed under a general category of 'way of life' which might be expected to be different in an area dominated by commuters and agriculture from that in an area dominated by heavy industry.

4.2.5 External Comparison Areas

Characteristics of the external comparison areas were summarised in Section 2.4. It was clear from that discussion that Fife is the most useful and sensible external area for comparative purposes, because it most resembles the shale area in all respects except shale production: coalmining was a major industry in Fife, and much of the mining region is interspersed with agricultural rural communities. Consequently, log-linear estimates of mortality risks have in this study been carried out and reported for shale relative to Fife, but not relative to Borders or Midlothian.

Indeed, much of what has been said about comparisons with the 'no shale rural' area also applies to The Borders, which was originally taken as a comparison area precisely because it was a non-industrial zone (apart from the textile industry which does have some very particular hazards). As with 'no shale rural', the comparisons appear to inform more about the mortality levels in an industrial opposed to a non-industrial zone rather than the specific hazards of shale, and so are unlikely to elucidate the risks of shale as a specific industry.

It is of interest however that, although the all-cause mortality levels in Borders are low for both sexes, female all cancer mortality does not differ from Fife and Midlothian, whereas Borders men have lower all cancer mortality rates than the other areas (Figure 3.15). This result suggests that for males the presence of (and by implication work in) heavy industry may be an important cause of raised levels of cancer in general, a point which would not have emerged had comparisons been restricted to industrial zones only.

4.3 All-Cause Mortality

4.3.1 1911-31

Both the life table analysis and the log-linear analysis confirm that the major mortality differences between shale activity areas in this period were in infant and childhood mortality. The life table analysis shows this effect through the much larger differences in e_0^0 than in e_{15}^0; the log-linear analysis shows larger relative risks when all ages are considered than when 15-74 alone is taken. Similarly the major changes over the two decades in all the areas were improvements in mortality which occurred in the early years of life. Those factors known to affect infant and child mortality: maternal nutrition and welfare, maternal education, housing, control of infectious diseases, availability of primary medical care, fertility levels - were all changing fast in the area at this time, as indeed they were throughout Britain. In principle, these factors may have been affected by the presence of the shale industry, where intervention by the shale companies was often a major determinant of social changes. However, the improvements to mortality in the early years of life occurred in all the shale activity areas (i.e. 'high shale' and 'low shale', 'no shale industrial' and 'no shale rural'), albeit at slightly different rates, indicating that the presence of the shale industry *per se* is unlikely to be an important determinant of the mortality changes.

Adult mortality is of course also susceptible to these influences, but might also be expected to reflect industrial conditions. Both the estimated relative risks and the probabilities of dying showed higher mortality in industrial areas than in the areas where there was little or no industry (i.e. 'no shale rural'). It seems to be the presence of industry, along with the inevitable living, working and general socioeconomic conditions generated by an industrial base to the economy, that is the principal influence on the overall mortality levels. The particular extractive industry concerned, whether it be coal, shale or a mixture, appears to have had no particular influence on all-cause mortality in this area. This is slightly surprising given that, at the time, the shale industry had a reputation for its paternalistic attitude to its workforce (but see Randall, 1990) whereas the coal industry tended to be perceived solely in terms of exploitation. Scottish coal workers had some of the lowest wages and the poorest housing in the UK (Church, 1986).

Of all the areas 'low shale' tended to have the highest adult mortality - at least for males - which is curious because those civil parishes involved, although containing both coal and shale industries to a small degree, also contained large areas of agricultural land. If the presence of the coal industry were the important determinant of mortality one would expect 'no shale industrial' to have highest mortality; if shale were the dominant factor, then the high shale area would be expected to be the leader. The relative pattern suggests that an industrial explanation alone is not satisfactory and that other socioeconomic conditions and 'way of life' are equally, if not more, important.

In all the areas and for both sexes the major fall in adult mortality occurred around 1920 (Tables 3.2 and 3.4). Paradoxically this was the period after the boom war years when wages in both coal and shale were high, and marked the beginning of the time of most industrial hardship; the period of strikes, soup kitchens, wage cuts, unemployment and poverty. However it was also the time when the majority of the population acquired housing with an internal water supply, flush toilet and more rooms than before. This was either through rehousing in council housing or through improvements and additions made to the existing 'rows'. Simultaneously the primary medical services were improving rapidly with provision of nurses and midwives, fertility was falling and working hours were being reduced (the latter was less systematic). It is possible that the reduction in employment was reducing exposure to industrial hazards and therefore reducing adult mortality; this seems unlikely since falls in employment meant increased poverty and certainly contemporary studies (Moser *et al*, 1984) indicate that unemployment is bad for health rather than good for it. Also such a mechanism would affect only males in the study area – as very few women worked in the industry – yet the fall in all-cause mortality levels was more marked for women.

The relationship between male and female mortality levels is possibly the most interesting feature of the 1911-31 data. In general it is expected that males will have higher all-cause mortality levels at all ages than females except possibly in the childbearing ages if maternal mortality is high. Table 3.7 indicates that in the high shale area women (15-64) suffered death rates equivalent to or even higher than those of men until the late 1920s. In the industrial and low shale areas the changeover occurred a decade earlier. Table 3.3 suggests that the pattern in the high shale area was achieved through an earlier fall in male mortality rather than persistent high female mortality; this provides yet more evidence that overall life and work in the shale communities was no worse for the population (in terms of mortality) and probably better for them at that time than life adjacent to other contemporary industries.

All males living in this area of Mid and West Lothian had significantly lower mortality than contemporary Scottish males. Several factors may be implicated here, but bearing in mind that for women, mortality was only lower than Scotland for all ages and not for adults 15-74, it is unlikely that social conditions were the only component of this lower mortality. It is true that in both shale and coal mining areas few men fought in the first world war. Although overseas deaths in the war were not part of annual death statistics in Scotland, many of those who died on return to Scotland were included. It might be thought that these deaths were boosting the Scottish male mortality statistics compared to the lower war participation in the study area. However, the patterns of the coefficients in the logistic analysis do not confirm this hypothesis – rather they suggest that the shale activity areas were always different from Scotland with the differences in male mortality widening slightly over the two decades studied.

Although the shale study area suffered in the depression of the 1920s and 1930s there was generally a reasonable level of work available, particularly in the shale industry; young people who couldn't find work tended to emigrate. Bearing in mind recent work on the relationship between unemployment and mortality (Moser *et al.*, 1984) it is possible that the higher levels of male adult mortality in Scotland as a whole reflected the general lack of work and insecurity which was not so strong in the shale study area.

The principal point to emerge from the 1911-31 analysis is that, in general, adult males in the high shale area had significantly lower mortality than males in Scotland and also lower mortality than males in the low shale and industrial areas; for females mortality was lower in the shale area than in the other areas but the differences were smaller than for males.

4.3.2 1963-81

This pattern of differences had changed substantially by the period 1963-81. By then male all-cause mortality in the shale area was similar to the overall Scottish levels, but men in the shale area had significantly higher mortality than men in either Fife or the 'no shale industrial' area (Table 3.8). Shale females had higher mortality than Scotland and Fife but had a similar level of mortality as the industrial area. The male excess is present at all ages for both cancer and non-cancer causes, but for adults 15-74 is only significantly higher than Fife for non-cancers.

The graphs of the annual variation in all-cause mortality suggest that male mortality was particularly high in the 1960s in the shale area, after which it diminished and the levels approached those in the other areas. This suggests that, for men, living in the shale communities was disadvantageous. That this disadvantage might be related to shale production is suggested because the time sequence of the mortality differences shows them to be greatest in the earlier years of the period 1963–81, that is closest to the time when shale was still being produced. However, if the direct effects of shale production alone had a major responsibility for these differences one would have expected them to be even more marked in 1911–31 when production and throughput of shale was at a much higher level than at any time during the 1950s and early 1960s.

That the excess mortality from all causes 1963–81 was restricted primarily to men suggests that if the shale industry was a factor, then its impact has either been directly through the work of the men employed in it, or indirectly through an adverse effect on lifestyle and living conditions in a way which affected men rather than women. That the excess mortality was found in the shale but not in the other industrial areas suggests further that if the shale industry was a factor, its impact (direct or indirect) was different from that of coal, and discernibly so in 1963–81 but not 1911–31.

These possibilities were therefore at the forefront of attempts to interpret, in the following section, the patterns of cause-specific mortality 1953 or 1963 to 1981.

4.4 Cause-Specific Mortality

The four major causes of death in the communities studied (and elsewhere in Scotland) are ischaemic heart disease, cerebrovascular disease, other circulatory diseases and respiratory cancer. Results from 1953–81 show that excess mortality from these causes, especially those related in some way to the circulatory system, explains the excess overall mortality in the shale areas over the same period which was noted above. For example, males in the shale area experienced higher death rates from IHD than men in Scotland, Fife and the 'no shale industrial' area. Death rates from cerebrovascular disease were also higher, in both males and females, in the shale areas relative to all Scotland, but not relative to the 'no shale industrial' area. Mortality from other circulatory diseases was high in the shale areas, for both males and females, relative to all other areas. Death rates from respiratory cancer were higher for the shale areas relative to 'no shale industrial' and to Fife, though not to Scotland as a whole (where the experience is dominated by the exceptionally high mortality in the Clydeside conurbation).

All four of these major causes of death are recognised as 'lifestyle' diseases, with mortality rates strongly influenced by diet, smoking, alcohol consumption and exercise patterns, and so it is sensible to look to these factors in the first instance for an explanation of the observed patterns. The evidence is not straightforward. On the one hand, although the shale areas have been described as communities, the interview material (Randall, 1990) gave no reason to believe that the presence of the industry had moulded the area to such a degree that distinct cultural and behavioural patterns had emerged; the communities were never that isolated from the adjacent industrial areas. Nor does it seem that working in the shale industry was an especially demanding way of life, compared (say) with working in the coal industry, and indeed the Provident Fund mortality study did not suggest that the shale workers studied had experienced excessive mortality from any of these four causes (Miller *et al*, 1986). Thus it is difficult to see a credible mechanism which would explain the excess mortality from these 'lifestyle' causes in terms of the presence of the shale industry *per se*. But neither does any of the methodological issues discussed in 4.2 above seem to provide a suitable explanation.

We think that a possible explanation of the excess deaths from IHD and other causes among men in the 'shale' area (relative to 'no shale industrial') is provided by the relationship, noted above, between unemployment and mortality (Moser *et al*, 1984).

The decline of the shale industry, and eventual cessation of production, is likely to have affected mortality among men rather than among women in the 'shale' area relative to 'no shale industrial': though coalmining in the study area was also in decline in that period, the closure of the shale industry was more marked. We look on this possibility as informed conjecture at present, because the relative rates of decline of the two industries, the extent of subsequent unemployment in the areas (taking account of any out-migration of unemployed men), and indeed the health effects of unemployment all need further study if the possibility were to be investigated rigorously; but we know of no other plausible explanation of the patterns found.

Patterns of mortality from some, rarer, causes of death were, however, clearly interpretable. Mortality from industrial lung disease (pneumoconiosis) was high in the shale area compared with all Scotland, but death rates in the 'no shale industrial' area were markedly higher still. Coding of this cause of death was reserved almost exclusively for ex-coalminers, and results are consistent with the proportion of men working in the coal industry in the two areas. The excesses are therefore almost certainly due to coalmining.

Mortality from psychoses, and (among females) from 'other internal causes', provides further examples of interpretable effects. Excess deaths from psychoses among those in the shale area were due primarily to senile dementia in people aged 80 years or more, while excess deaths from other internal causes among females in the shale area (relative to Fife) consisted primarily of neonatal and infant deaths. Both excesses are attributable to the fact that the shale area includes Bangour General Hospital, a major hospital serving a wide area of West Lothian. Deaths among patients at Bangour General and its associated mental hospital were attributed to the Civil Parish of ordinary residence rather than the Civil Parish where the hospitals are located, except for people who had been patients six months previously, or infants born in the hospital who died without leaving it. It is highly unlikely therefore that the hospital contributed to the excess mortality from 'lifestyle' causes in the shale area, discussed above.

Although these findings regarding industrial lung diseases, psychoses, and 'other internal causes' are not informative about the risks, if any, of working in or of living near an active shale industry, they do show that the study as carried out was powerful enough to detect excess mortality, in relative rare causes of death, in instances where there were factors known or likely to affect mortality from these causes in particular. To that extent, they may aid in the interpretation of results from several rare cancers which are '*a priori*' most likely to be the result of work in, or the presence of, the shale industry, and where excess mortality was found.

Consider first skin cancer, where an excess was indicated both in men and women, relative to all other comparison areas. Numbers of deaths were small, and so the excesses were not statistically significant. The link between skin cancer and work in the shale industry is nevertheless a long-established one, and was re-affirmed by results from the PF mortality study (Miller *et al*, 1986). Cross-reference between data from the Provident Fund and the present mortality studies showed that the evidence of a skin cancer excess among men in the present study was provided by men who had also been included in the PF results. Consequently, the excess skin cancer mortality among men, noted now, should not be considered as additional further corroboration of a relationship, though the suggested finding of an excess among women also in the present study is genuinely new information.

The other two sites of malignancies where results were of particular interest were bladder and 'other' genito-urinary cancer. Mortality from bladder cancer showed a statistically significant increase among women in the shale area relative to other comparison areas; the relative risk for men was also elevated, but not to a statistically significant degree.

Previous hypotheses suggest that shale exposure may be linked to bladder cancer, and an association is plausible biologically; we interpret the present findings as suggestive of a real effect. Finally, mortality from 'other' genito-urinary cancer was increased among men relative to other comparison areas; results from the case-control study confirmed that it may also be related to work in shale-related occupations. Again, an association is plausible biologically, and we think that the present findings are suggestive of a real effect.

4.5 Conclusions

Much of what was most informative about the present study of mortality in the shale-producing communities of West Lothian in Scotland has been by way of contrast between mortality in the shale areas, and in adjacent industrial areas dominated by coalmining. Shale and coal mining are both major extractive industries which may affect the health of local communities not only by direct impact of environmental exposures or other hazards of work, but also indirectly through impact on lifestyle and living conditions. Indeed, where mortality in the shale areas has been higher than expected relative to elsewhere in Scotland, the most challenging aspect of interpretation has been to identify, as far as possible, to what extent this excess is attributable (either directly or indirectly) to the presence of the shale industry specifically, or to the presence of a major extractive industry, or to other factors.

Despite the inherent difficulties, some conclusions may be drawn.

(i) Detailed knowledge of social and other characteristics of the local situation is essential in carrying out such a study reliably, and in interpreting its findings.

(ii) It is essential also in evaluating the impact of the industry:

  (a) to consider both any direct 'mechanistic' effects of environmental exposures or other conditions of work, and indirect effects mediated through lifestyle and living conditions;

  (b) to distinguish if possible whether any effects, either direct or indirect, may be attributable to the influence of the shale industry specifically, or may be common to the presence and influence of any major extractive industry, irrespective of product.

(iii) It is possible for a study of this sort, carried out carefully, to show interpretable differences in mortality patterns between subgroups, distinguished by place of residence or other factors. This is especially so where the cause of death of interest is rare. Examples from the present study include mortality 1963-81 from industrial lung diseases (pneumoconioses), psychoses, and neonatal or infant mortality, where excesses were found, but these were not shale-related.

(iv) Skin cancer, bladder cancer and (among men) 'other' cancers of the genito-urinary system are other relatively rare conditions which may be related to work in, or the presence of, the shale industry; leading, in the conditions prevailing in Scotland 1953-81, to excess mortality from these causes. An association with skin cancer is very likely, while an effect of shale on the other two causes is both indicated by the data, and biologically plausible.

(v) It has not been possible to determine what effect, if any, the shale industry played directly or indirectly in excess mortality from major causes of death such as ischaemic heart disease; cerebrovascular disease; other diseases of the circulatory system; and respiratory cancer. These major causes of death are multi-causal, involving many aspects of lifestyle. Some patterns of excess mortality from these causes in the shale areas were noted. We think, in the light also of the related mortality studies of Miller *et al* (1986), that any direct effect of the shale industry was at most small, and dominated by other, 'lifestyle', factors. Nor are there obvious ways in which, in the industrial communities of West Lothian 1963–81, these lifestyle factors were influenced to any markedly different degree by the presence of the shale, rather than the coal mining industry. A review of the methodological difficulties noted in the course of the study did not provide any reasonable interpretation. The patterns of excess mortality from these major causes therefore remain unexplained, though increased mortality related to unemployment as a consequence of the decline and cessation of shale production is a plausible cause of the excess mortality found.

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We thank Christine Rae, David Salmond and George Baird of the General Register Office for Scotland (Ladywell House); George P MacKenzie of GRO(S) (New Register House); Dr JVM Heslop of British Petroleum (Grangemouth); Dr Una Maclean (University of Edinburgh); Professor William M Marine (University of Colorado); and several current and former colleagues at the Institute of Occupational Medicine, in particular Dick Annis, Virginia Henriksen, Ann Kinnear and Dr Brian Miller.

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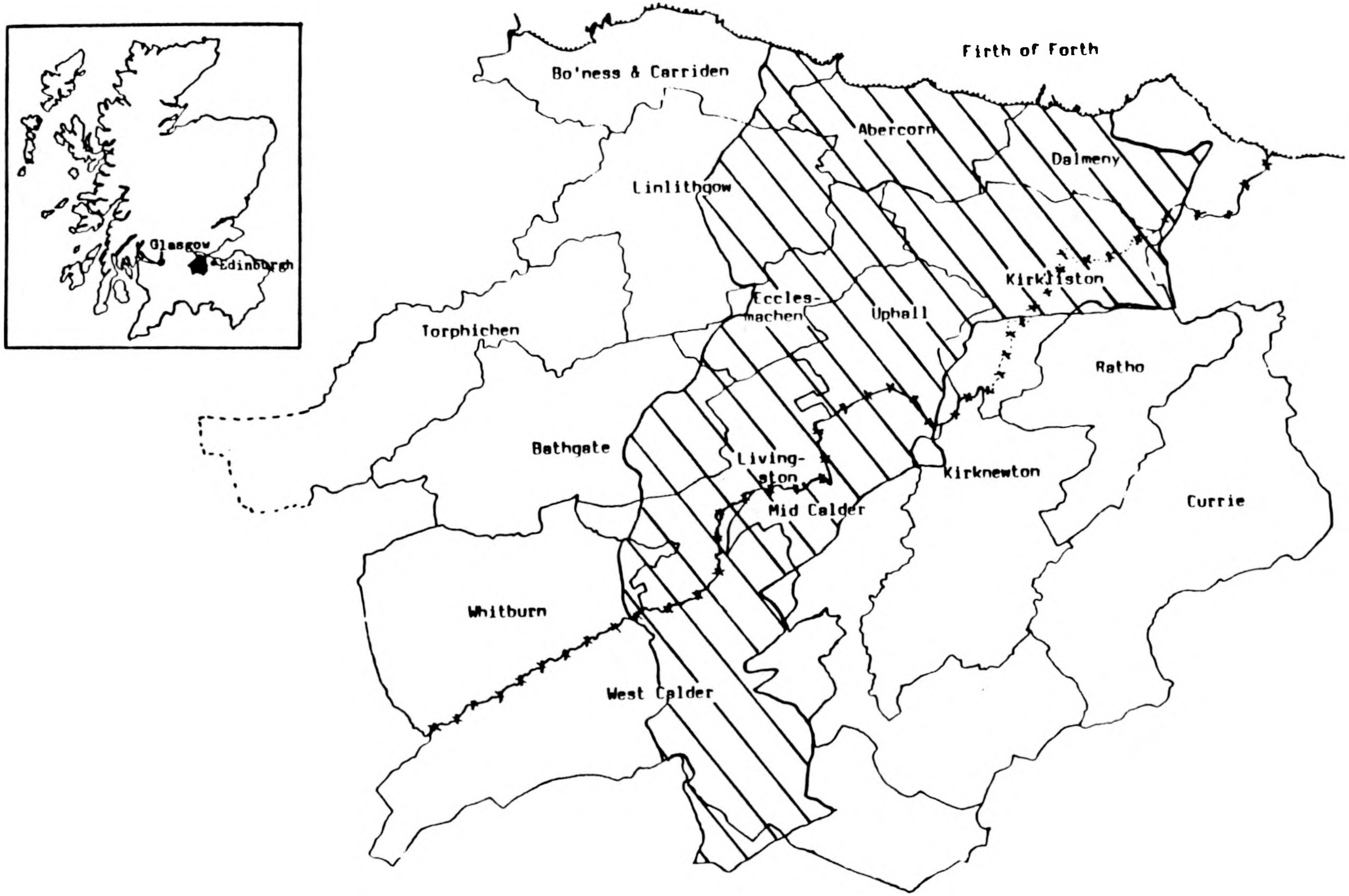


Figure 2.1 The Lothian shale field and civil parishes covered by it.

LEGEND:

Shale field (Source: The oil shales of the Lothians, Scotland: Present resources and former workings. Institute of Geological Sciences Report 78/28.)

Civil parish boundaries.

Boundary between Midlothian and West Lothian.

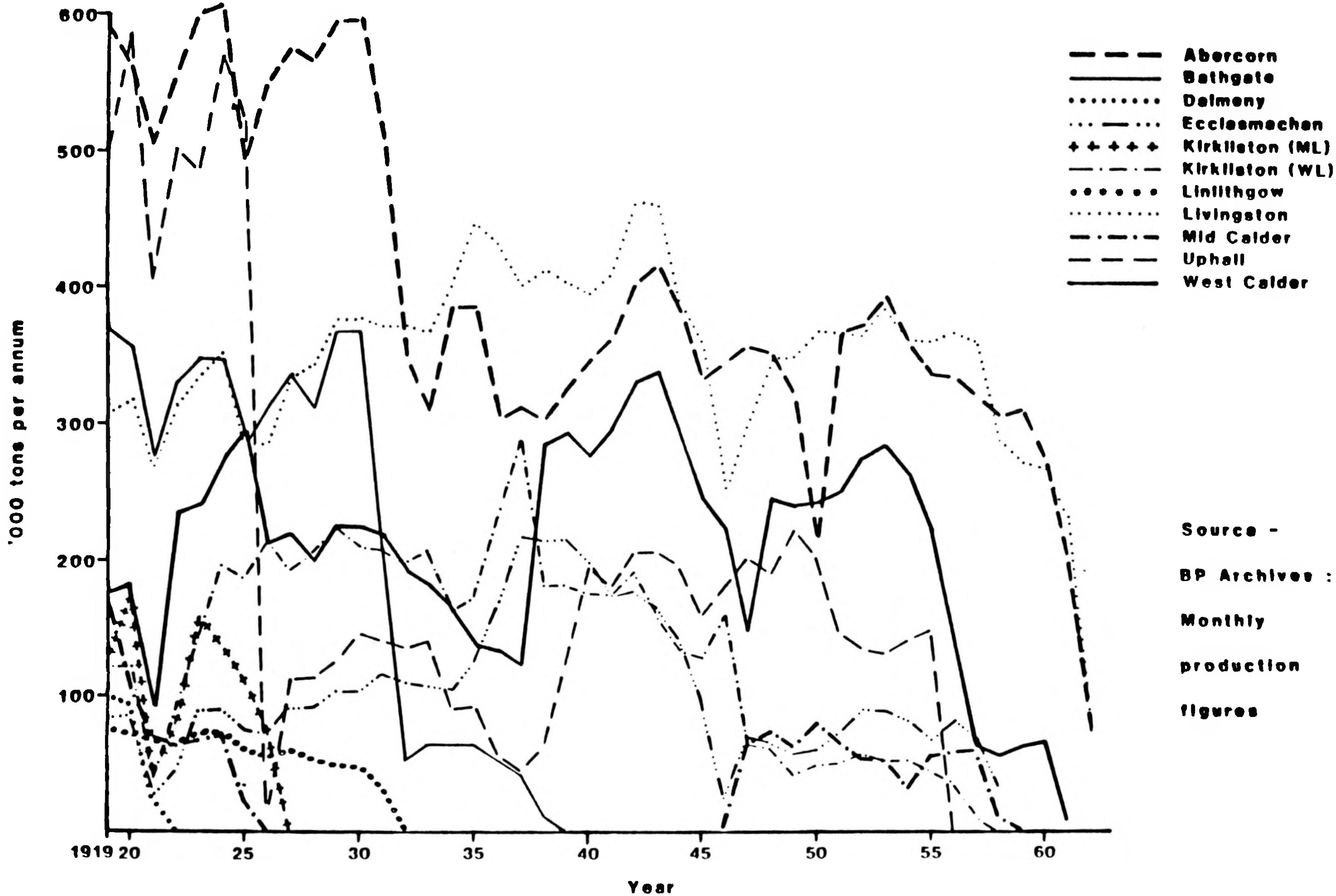


Figure 2.2 Shale production by civil parish, 1919-62.

Figure 2.3a Scotland: Counties before 1974.

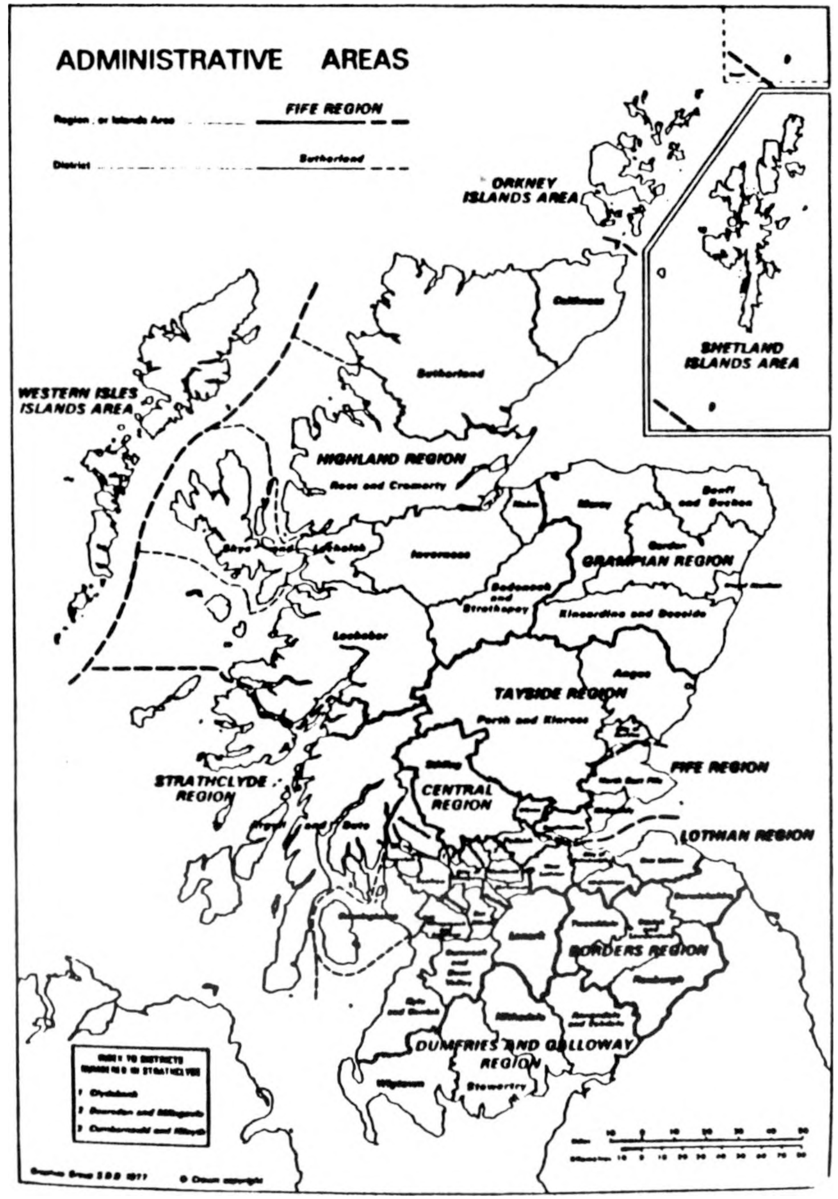


Figure 2.3b Local Government Regions and Districts, 1975.

(Reproduced from the 1974 Registrar General Scotland's Annual Report with the permission of the Controller of Her Majesty's Stationery Office.)

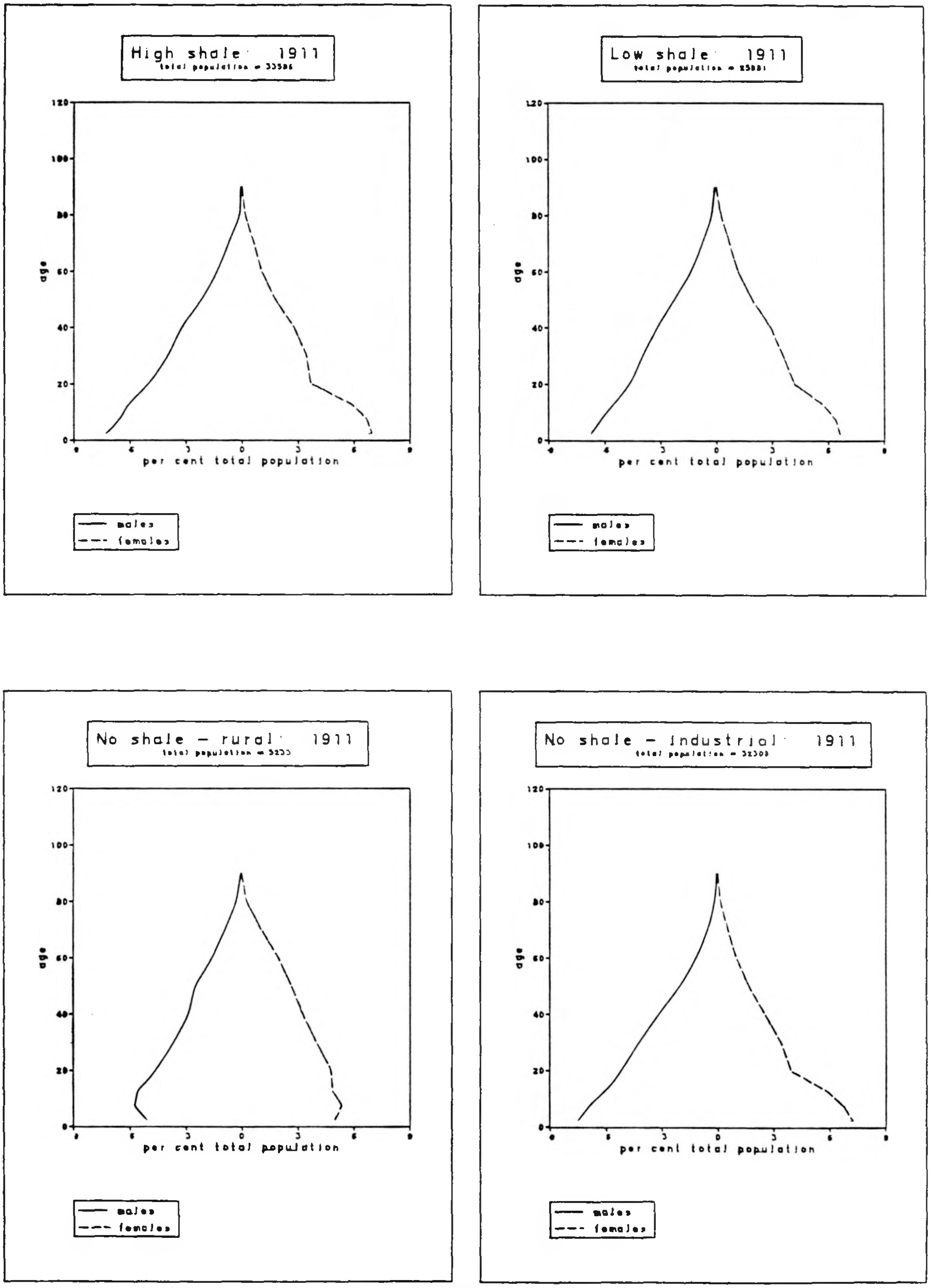


Figure 3.1 Age-sex distributions of the shale activity areas, 1911.
Source: Census, 1911.

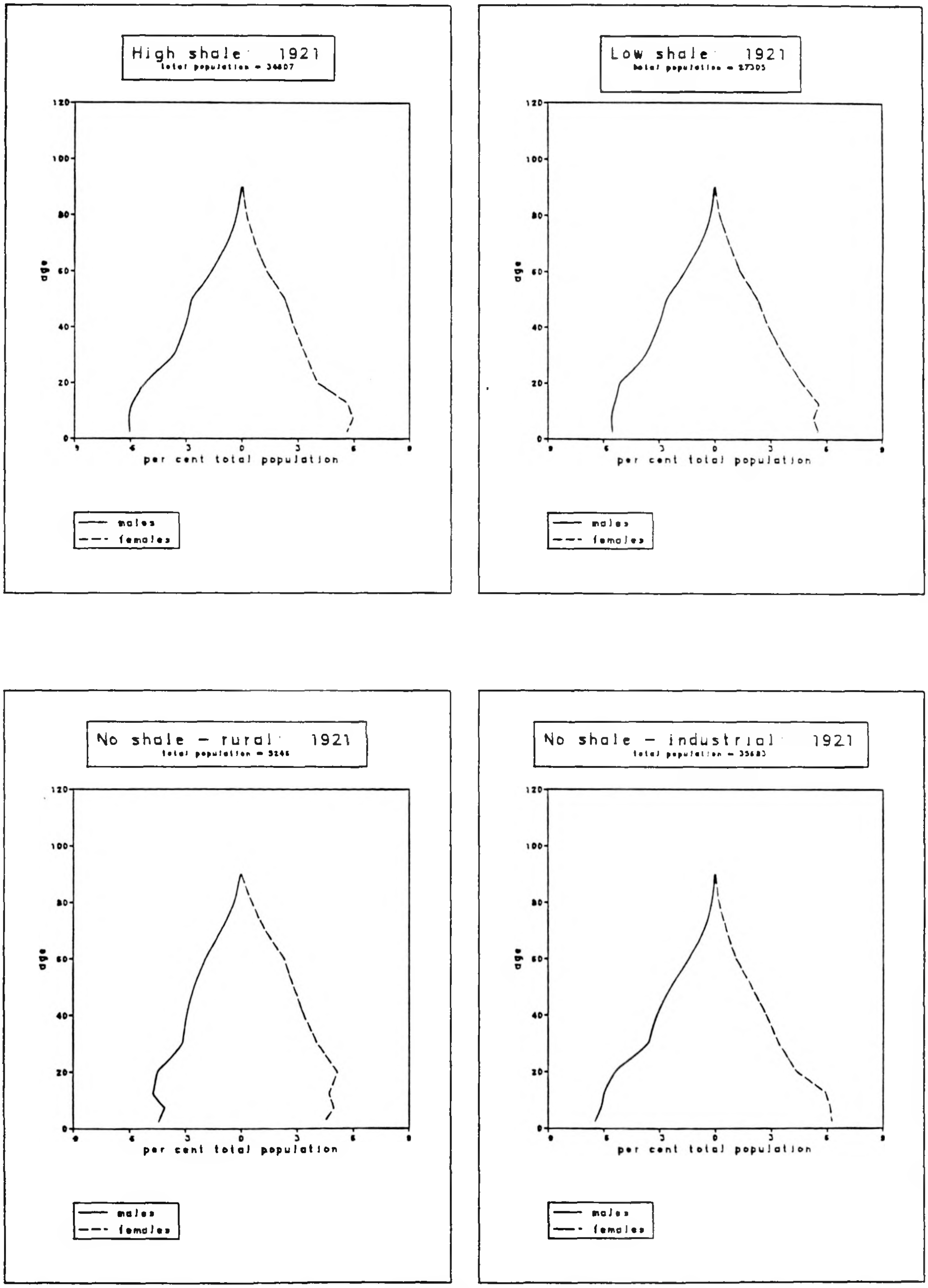


Figure 3.2 Age-sex distributions of the shale activity areas, 1921.
Source: Census, 1921.

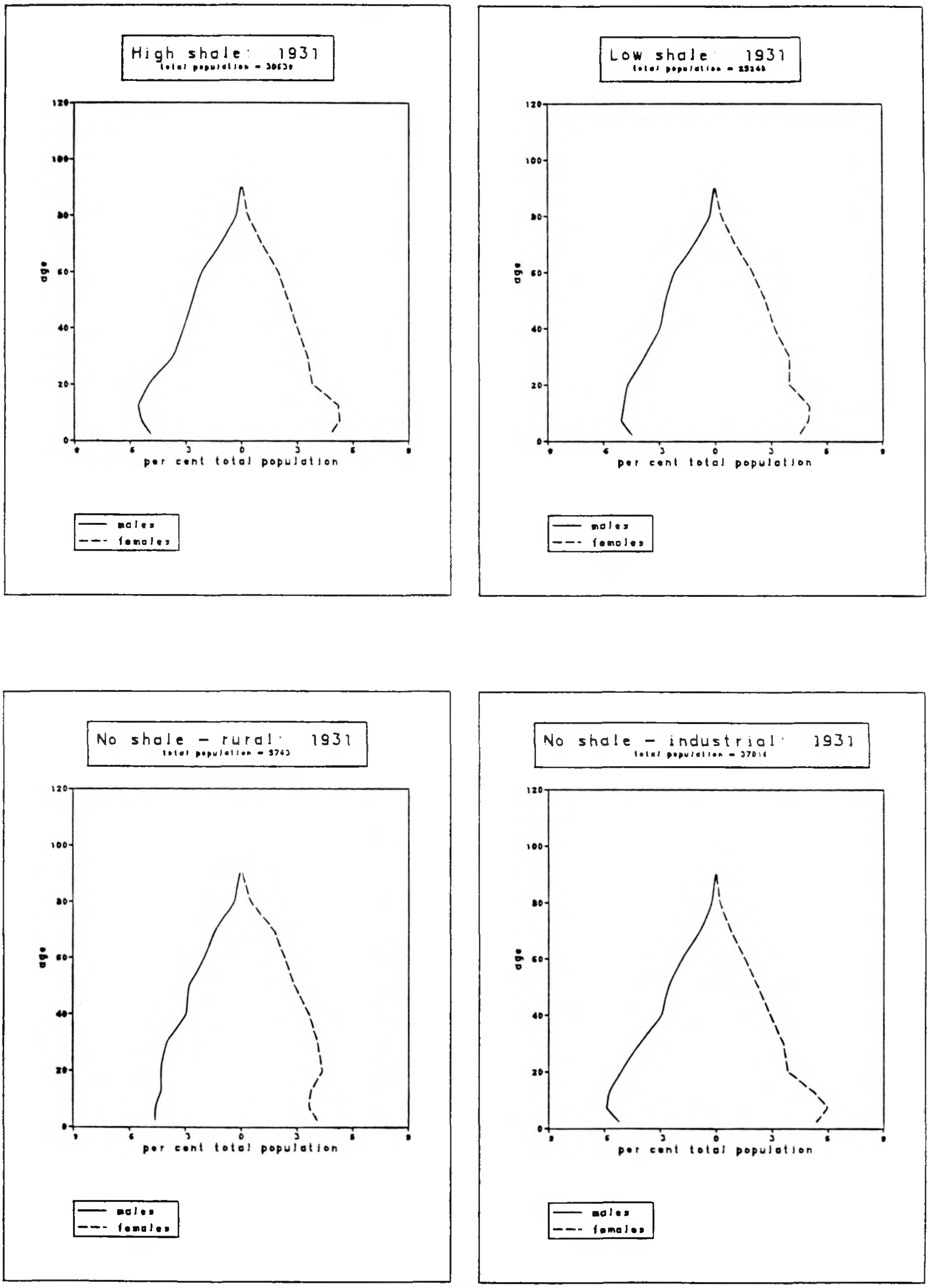


Figure 3.3 Age-sex distributions of the shale activity areas, 1931.
Source: Census, 1931.

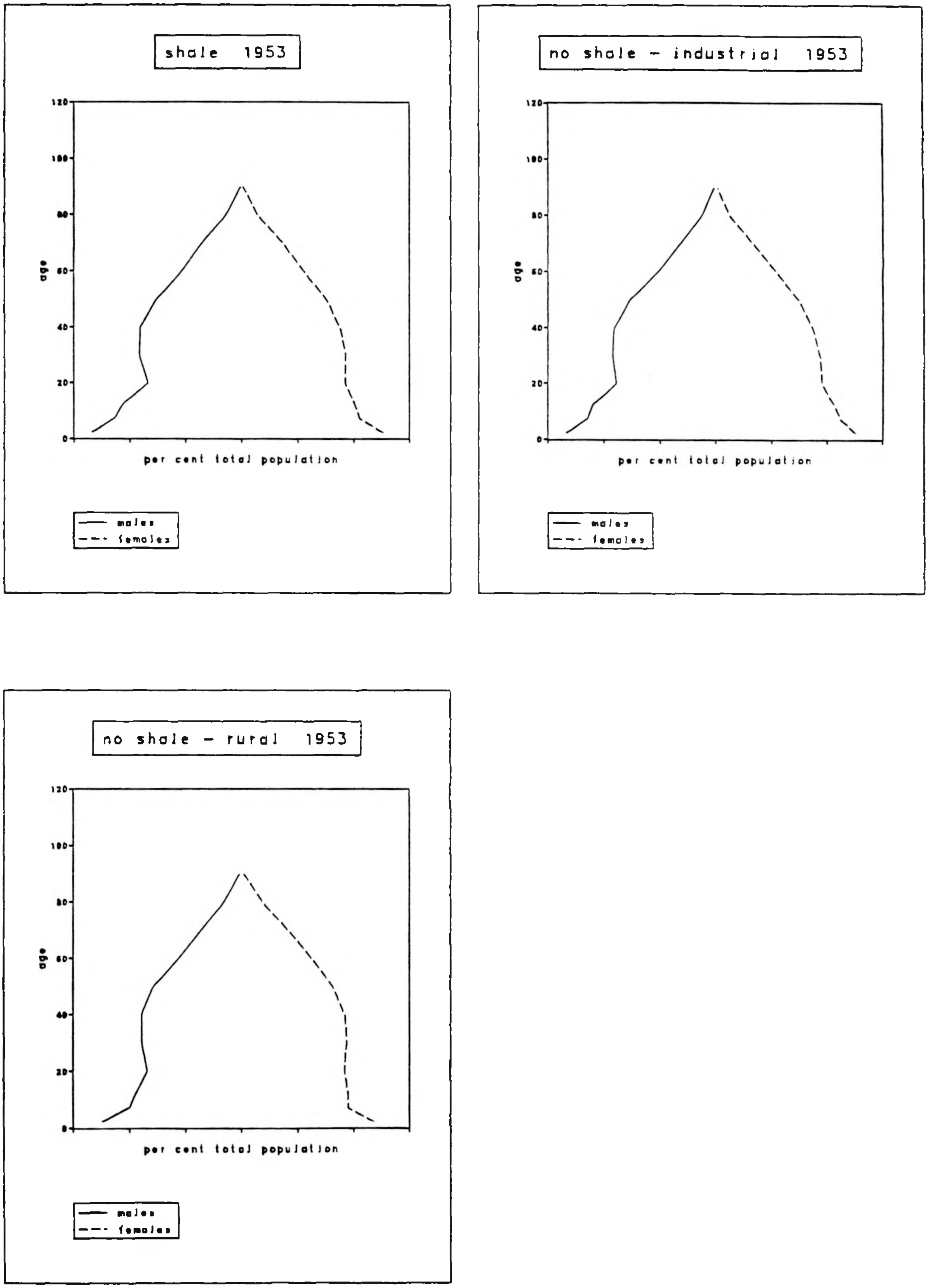
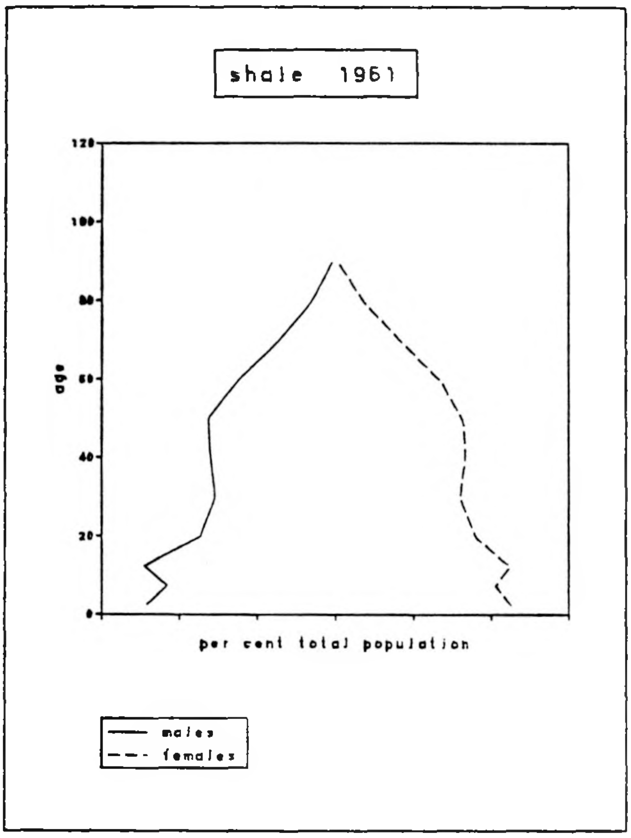
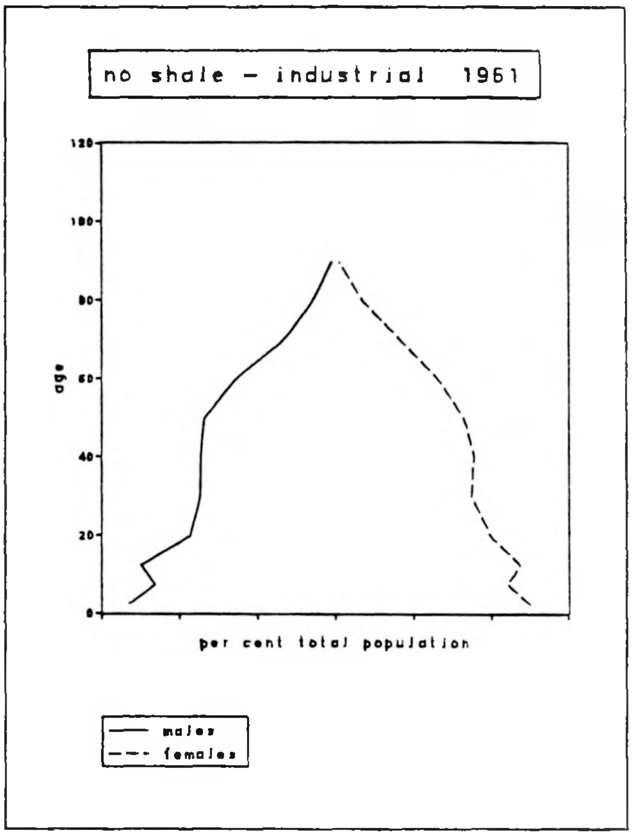


Figure 3.4 Age-sex distributions of the shale activity areas, 1953.
Sources: Census 1951, Census 1961 (interpolation).





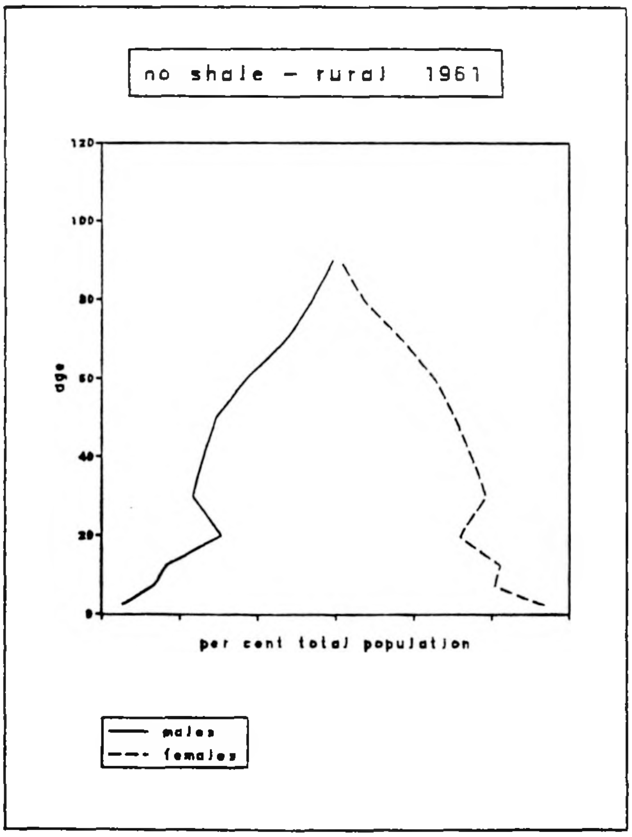


Figure 3.5 Age-sex distributions of the shale activity areas, 1961.
Source: Census, 1961.

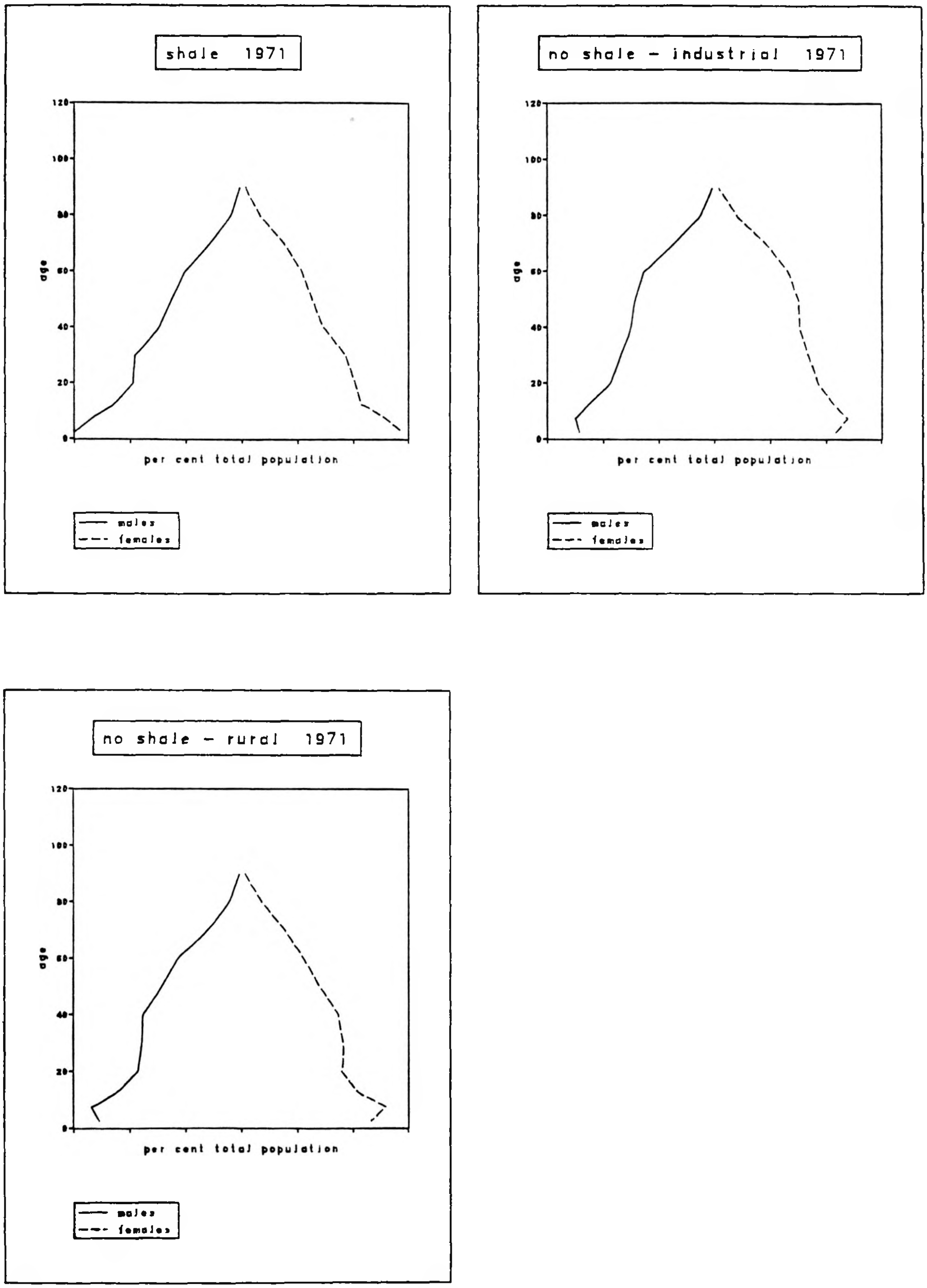


Figure 3.6 Age-sex distributions of the shale activity areas, 1971.
Source: Census 1971, small area statistics.

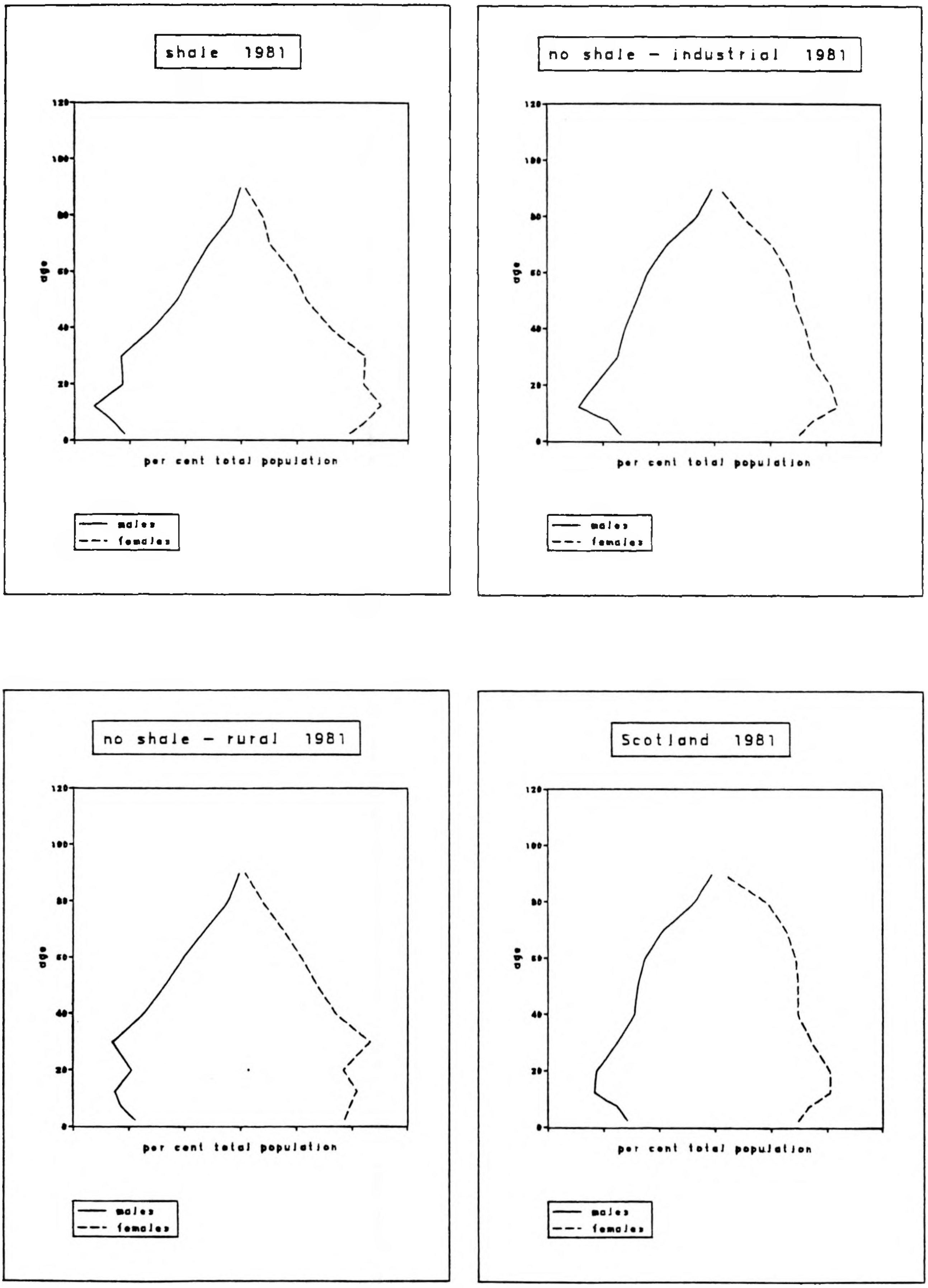


Figure 3.7 Age-sex distributions of the shale activity areas, 1981.
Source: Census 1981, small area statistics.

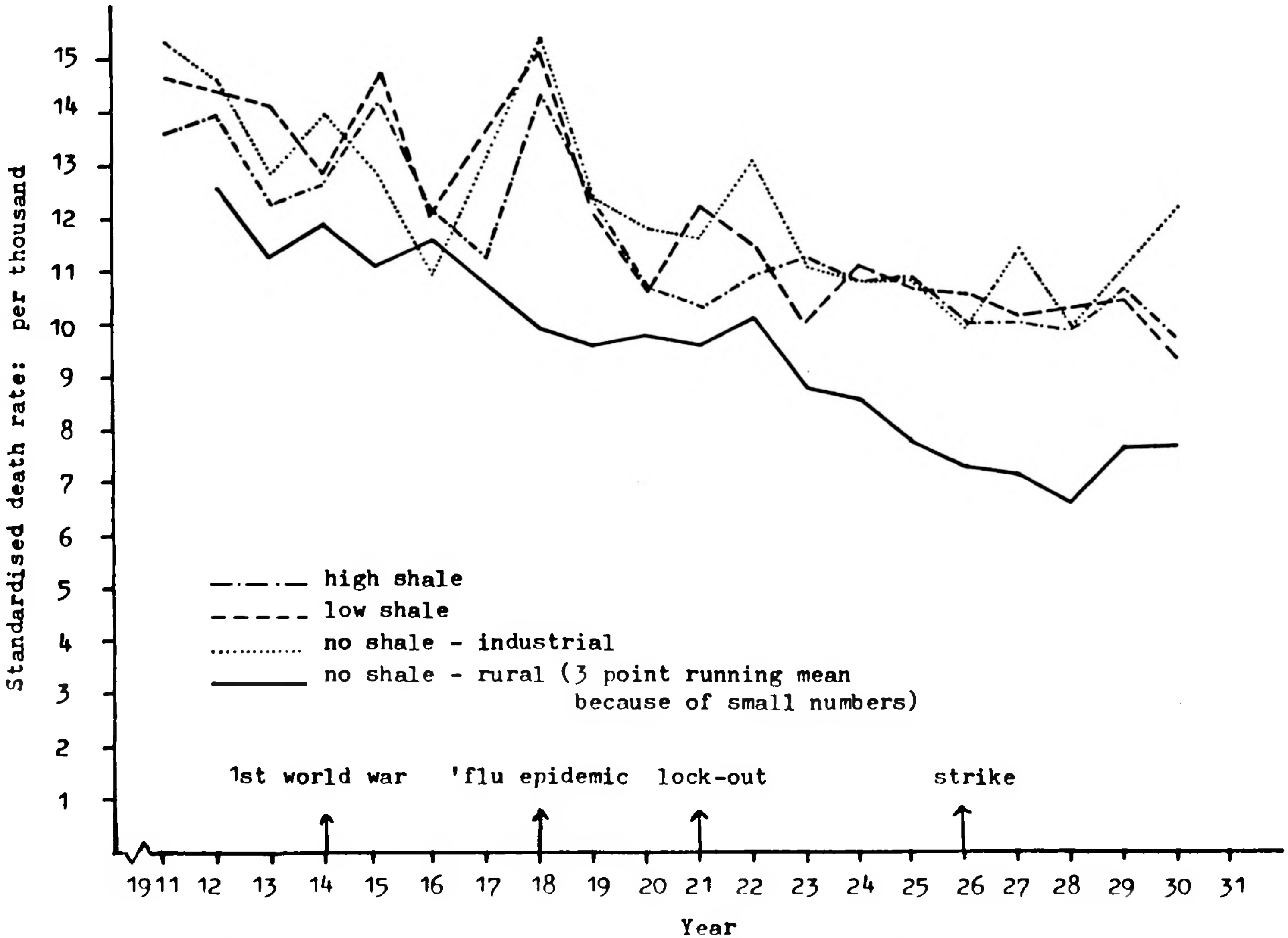


Figure 3.8 Directly standardised death rates - both sexes combined.
Using Scotland 1921 population as standard.

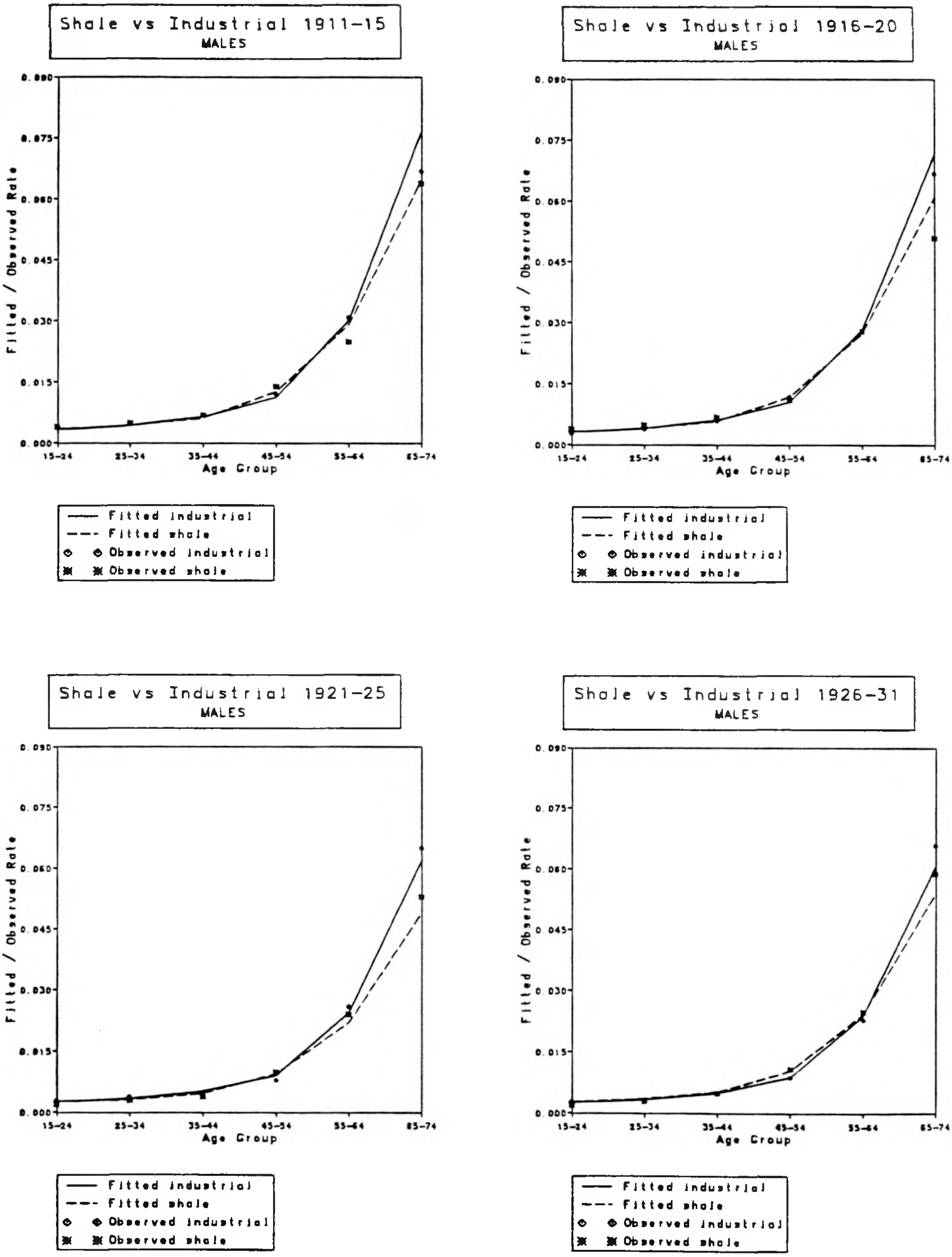


Figure 3.9 Observed and fitted age-specific death rates for shale and industrial (coal) activity areas, 1911-31: Males.

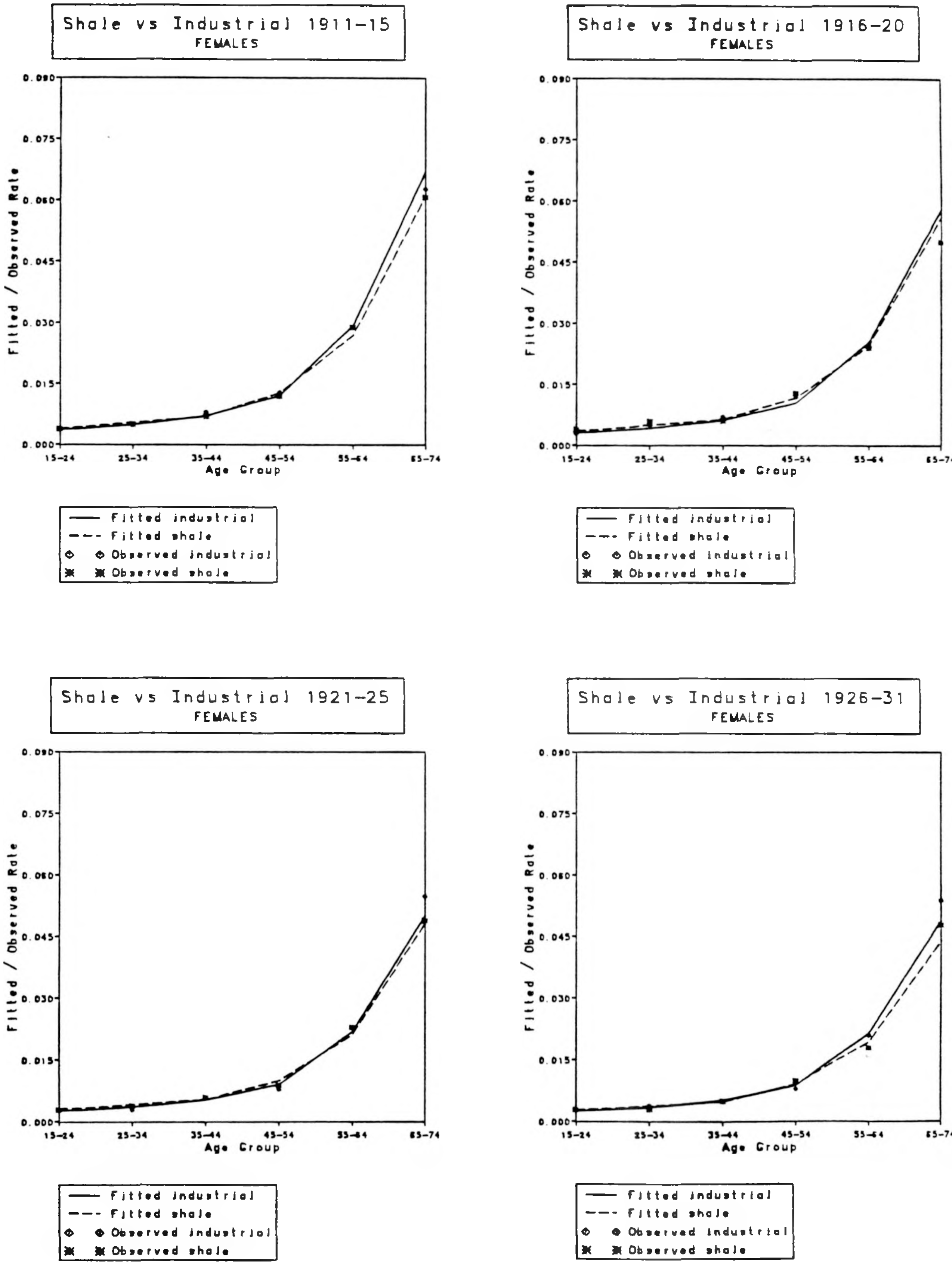


Figure 3.10 Observed and fitted age-specific death rates for shale and industrial (coal) activity areas, 1911-31: Females.

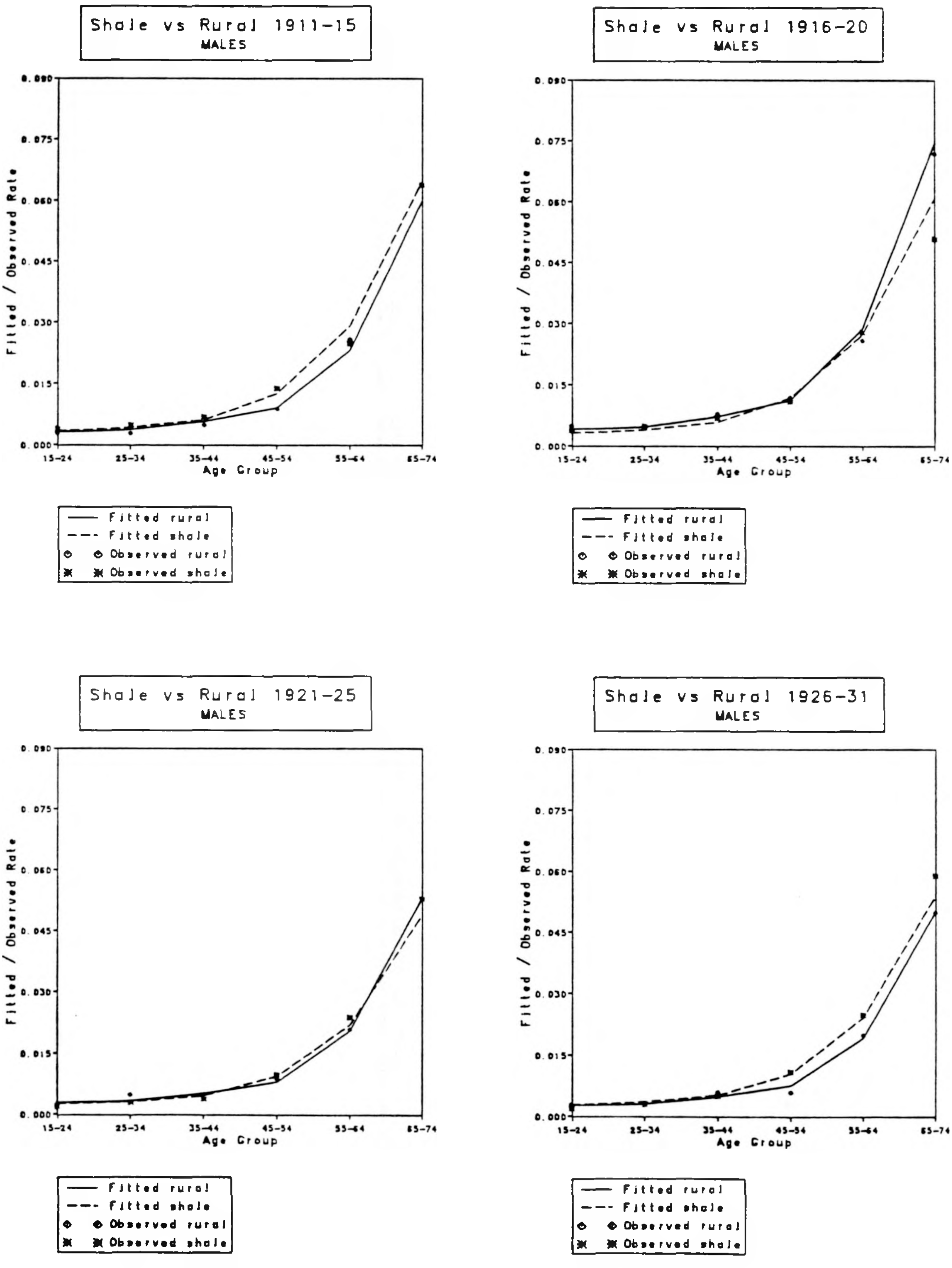


Figure 3.11 Observed and fitted age-specific death rates for shale and rural (non-industrial) activity areas, 1911-31: Males.

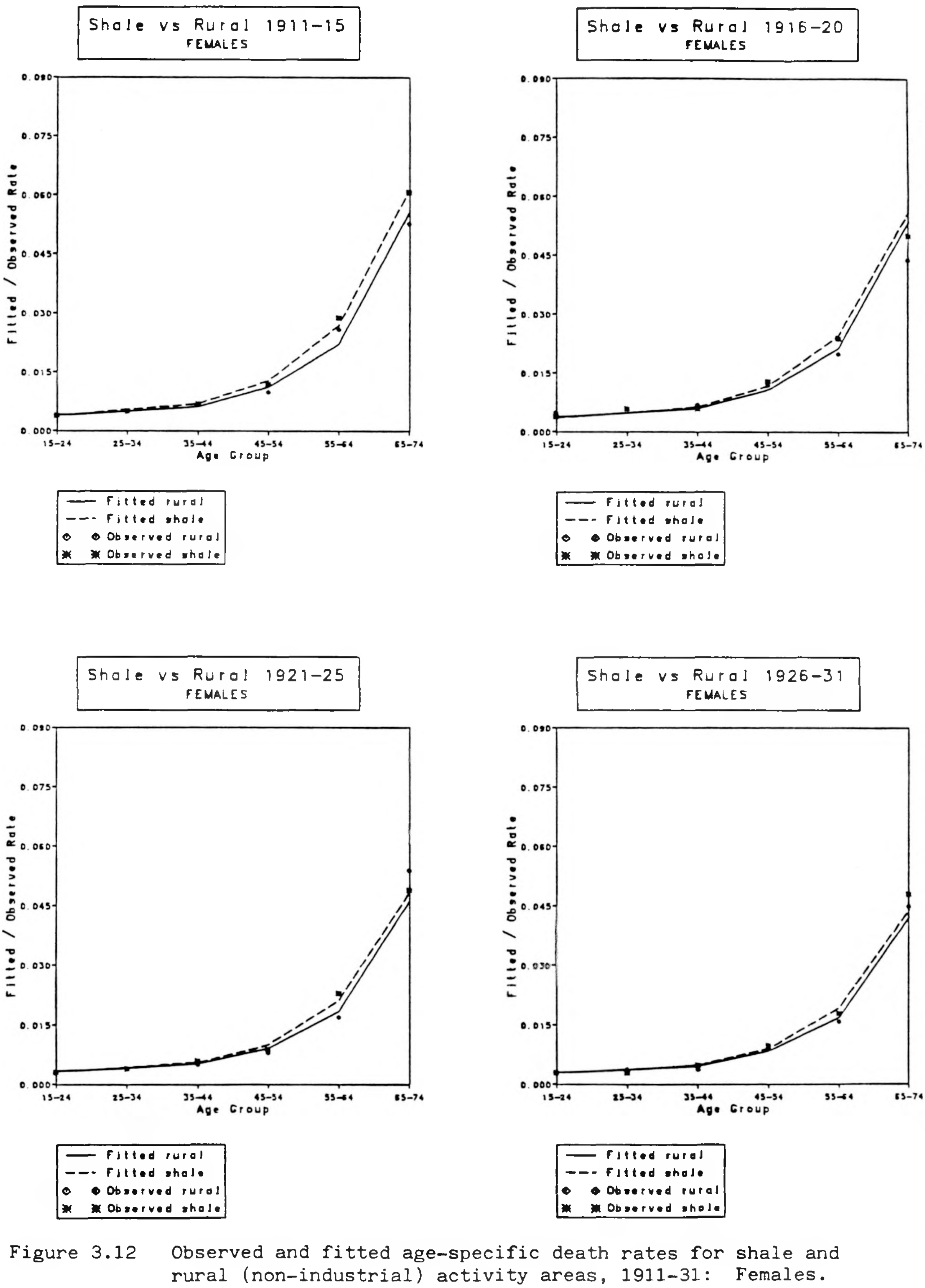


Figure 3.12 Observed and fitted age-specific death rates for shale and rural (non-industrial) activity areas, 1911-31: Females.

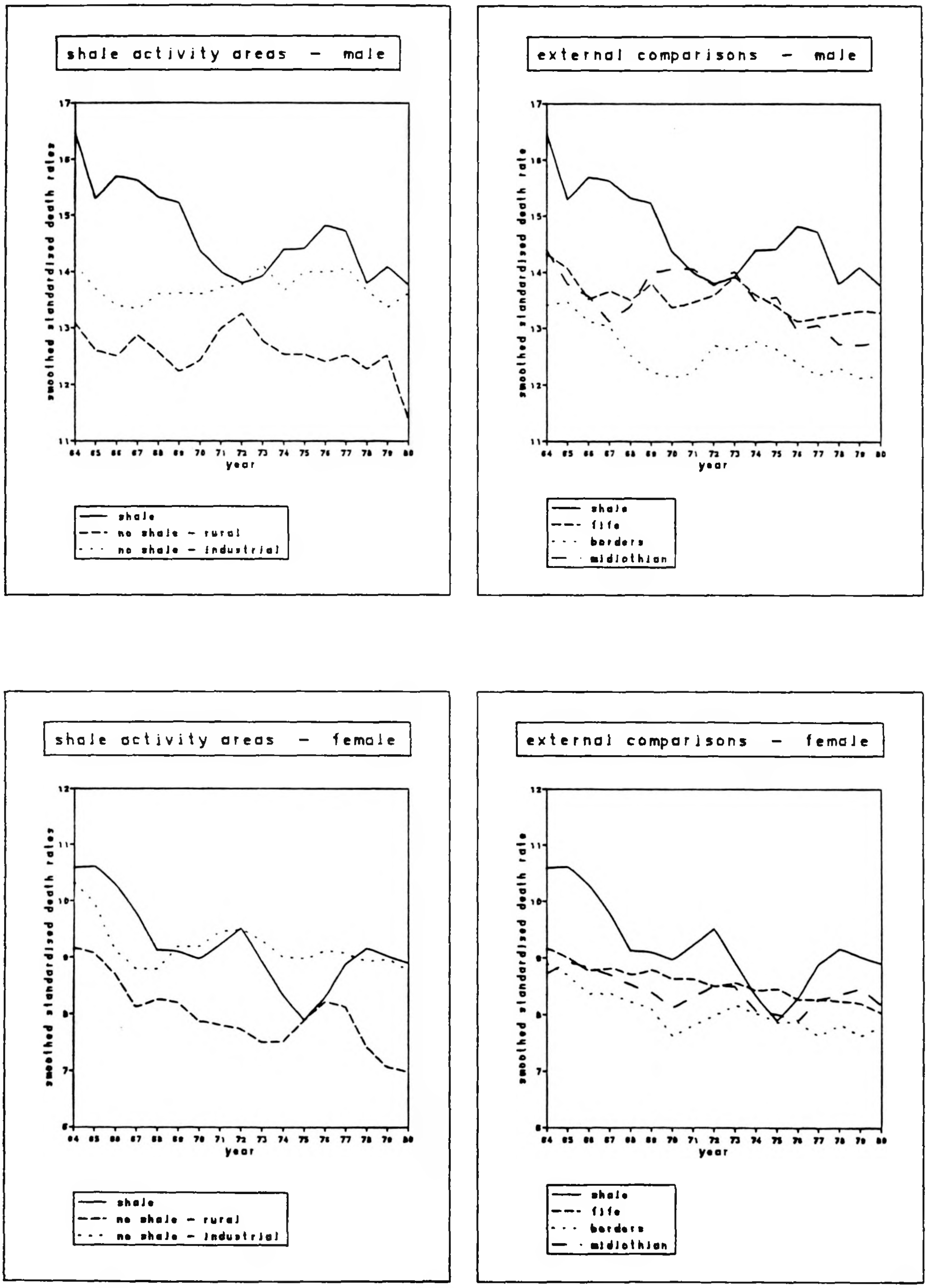


Figure 3.13 Standardised death rates (per 1000), 1964-1980, smoothed using a three-point running mean, for shale activity areas and external comparison regions: for males and for females.

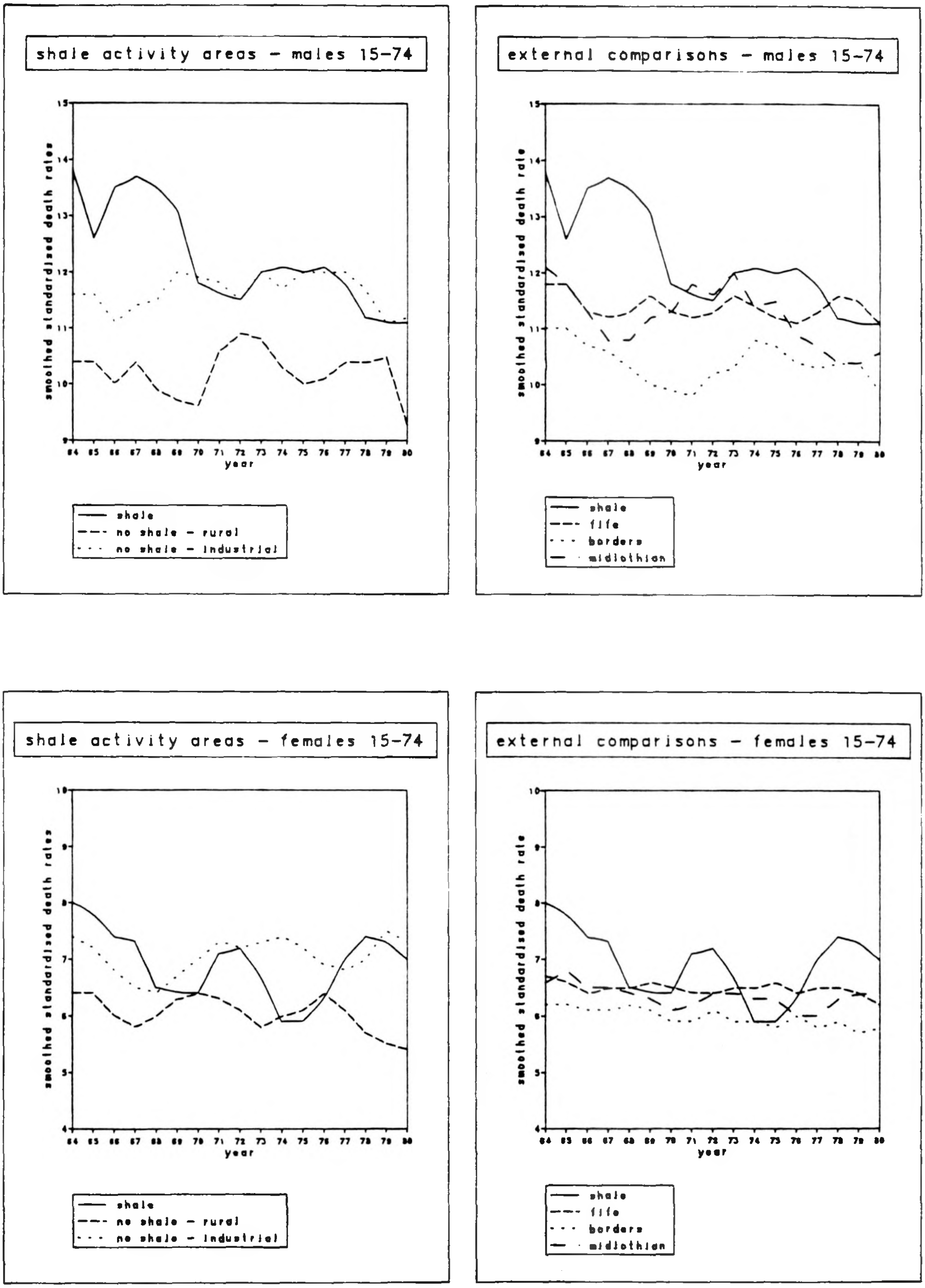


Figure 3.14 Standardised death rates (per 1000), 1964-1980, ages 15-74, smoothed using a three-point running mean, for shale activity areas and external comparison regions: for males and for females.

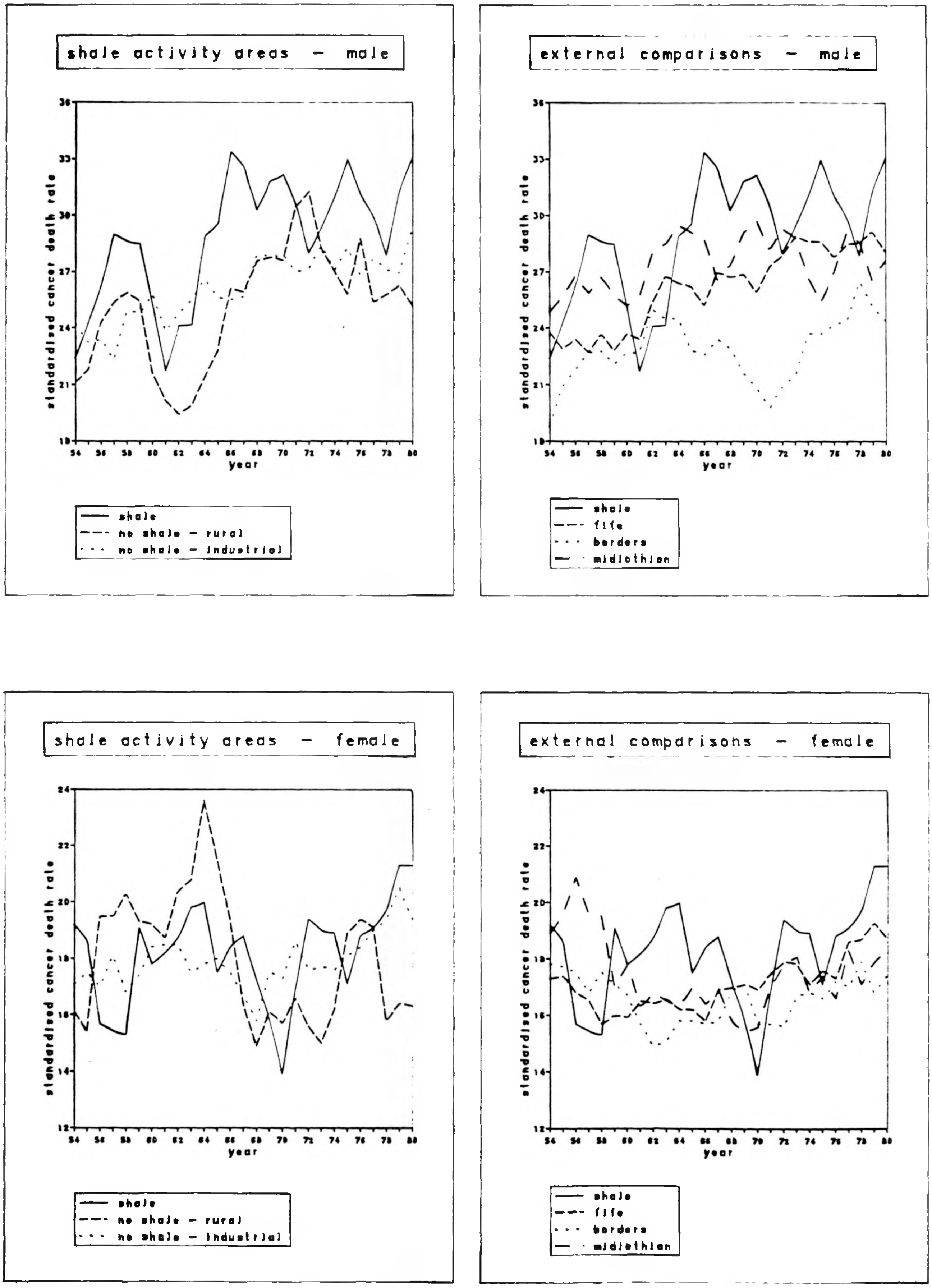


Figure 3.15 Standardised all cancer death rates (per 1000), 1954-1980, smoothed using a three-point running mean, for shale activity areas and external comparison regions: for males and for females.

Table 2.1 Classification of shale study area civil parishes.

Civil Parish	1911-31 4 Groups*	1911-31 3 Groups*	1953-81
Currie	NSR	NS	NSR
Ratho	NSR	NS	NSR
Kirkliston ML	NSR	NS	NSR
Kirkliston WL	HS	SHALE	SHALE
Abercorn	HS	SHALE	SHALE
Uphall	HS	SHALE	SHALE
Livingstone	HS	SHALE	SHALE
Mid Calder	HS	SHALE	SHALE
West Calder	HS	SHALE	SHALE
Ecclesmachan	HS	SHALE	excluded**
Dalmeny	LS	SHALE	NSR
Linlithgow	LS	NS	NSR
Kirknewton	LS	SHALE	NSR
Bathgate RD+	LS	COAL	NSI
Armadale RD+	NSI	COAL	
Bo'ness & Carriden	NSI	COAL	NSI
Torphichen	NSI	NS	NSI
Whitburn	NSI	COAL	NSI

* Classification into groups is described in Section 2.3.

4-group classification

HS = high shale
LS = low shale
NSR = no shale rural
NSI = no shale industrial

3-group classification

SHALE
COAL (or Industrial)
NS = No Shale (or Rural)

** Ecclesmachan was excluded from the 1953-81 analysis because the presence of Bangour General Hospital distorted the data and the population and could not be satisfactorily controlled for.

+ In the 1911-31 analysis Bathgate and Armadale were split into their respective registration districts. This was not necessary for the later analysis.

Table 2.2 Indices of industrial activity in external comparison areas: percentage of total population working in each industry or occupation. (Source: Decennial Censuses 1951, 1961, 1971).

	Fife	Midlothian	West Lothian	Borders	Scotland
1951					
coalminers	7.7	10.5	7.9	0.0	1.8
chemicals etc	0.5	1.2	1.5	0.1	0.6
iron foundries	0.1	0.0	1.6	0.0	0.4
1961					
coalmining	6.9	10.1	7.2	0.0	
chemicals etc	0.1	0.5	0.7	0.0	
metal manuf.	0.6	0.1	1.9	0.1	
1971					
coalminers	2.3	4.9	3.2	0.0	
chemicals	0.2	0.1	0.1	0.1	
metal manuf.	0.3	0.4	1.6	0.0	

For each census the classification of occupations changes as do the occupational and industrial tables presented. Here they are standardised as much as possible.

1951 data: numbers of (male) workers by county of work.

1961 data: 10% samply only: male workers in each industry (Industrial Orders).

1971 data: 10% sample only: industrial activity (by Industrial Orders).

Table 2.3 Sources of census data for estimating populations at risk.

1911:	Civil parish age-sex populations published (5-year age groups).
1921:	Civil parish age-sex populations published (10-year age groups after age 15).
1931:	District of County (D of C) and small burgh age-sex populations published (5-year age groups). Totals by sex published for civil parishes. Civil parish age-sex populations estimated proportionally using age distribution of the appropriate D of C.
1951/61:	No appropriate published data available. Age-sex distributions (single year ages) extracted for civil parishes from the original census records at General Registrar's Office (Scotland).
1966:	Sample census, 100% coverage in parts of shale study area. Age-sex populations for Districts of County. For those civil parishes where D of C coincided with the civil parishes, the 1966 population was used. The other populations were used to check validity of assumptions about intercensal population change.
1971/81:	Computerised small area statistics (SAS) available of census data: tables at civil parish level (5-year age groups).

For Bathgate and Armadale Registration Districts used in 1911-31, the total population by sex was available, together with the age-sex distribution of the small burghs which comprised the majority of the population in each RD. The residual population was divided proportionate to the District of County age distribution.

Table 2.4 Characteristics available for study from death certificates for various periods, 1953–1981.

	53-63	64-70	71-73	74-81
Registration Year	X	X	X	X
Registration month	X	X	X	X
Entry number	X	X	X	X
Registration District	X	X	X	X
Allocation code	X	X	X	
Occupation	X	X	X	X
Social Class	X	X	X	X
Sex	X	X	X	X
Age	X	X	X	X
Primary Cause of death	X	X	X	X
Place of accident		69-70	X	X
Post Mortem		X	X	X
Seen after death		66-70	X	X
Residence status		X	73	
Date of death				X
Time of death				X
Local Government Region				X
Health District				X
Local Govt Dist				X
Date of birth				X
Secondary causes of death				X
Post code				X

Table 2.5 Smallest areas of usual residence coded.

1953–61:	Small burghs, county landward.
1952–63:	Small burghs, district of county.
1964–74:	Small burghs, district of county, New Towns within D of C.
1974–81:	Postcode units: i.e. approximately 30 houses. Can be amalgamated up to any level including civil parishes.

Table 3.1 Expectation of life at birth ($\overset{o}{e}_0$) and expectation of life at age 15 ($\overset{o}{e}_{15}$) for shale activity areas, 1911–30 by sex.

	High Shale	Low Shale	No Shale Industrial	No Shale Rural
Males $\overset{o}{e}_0$				
1911-15	52.9	51.9	51.5	56.9
1916-20	54.1	53.2	53.3	57.8
1921-25	58.1	54.8	55.8	60.5
1926-30	58.4	58.3	56.6	62.8
Females $\overset{o}{e}_0$				
1911-15	53.9	52.4	53.2	58.9
1916-20	55.5	54.7	54.9	61.3
1921-25	58.1	59.7	57.2	61.9
1926-30	61.5	60.4	58.6	67.9
Males $\overset{o}{e}_{15}$				
1911-15	49.5	49.2	49.6	50.1
1916-20	49.8	49.0	49.6	50.8
1921-25	52.5	51.2	51.8	54.9
1926-30	51.4	51.4	52.2	53.1
Females $\overset{o}{e}_{15}$				
1911-15	49.3	49.0	48.2	51.3
1916-20	50.3	50.0	50.2	51.8
1921-25	52.3	52.1	51.9	54.7
1926-30	52.9	52.9	51.9	56.2

Table 3.2 Ratios of $\overset{o}{e}_0$ and $\overset{o}{e}_{15}$ for shale activity areas and 5-year periods for 1911-1930 to $\overset{o}{e}_0$ and $\overset{o}{e}_{15}$ in 1911-15 in "High Shale" area (by sex).

	High Shale	Low Shale	No Shale Industrial	No Shale Rural
Males $\overset{o}{e}_0$				
1911-15	1.00	.98	.97	1.08
1916-20	1.02	1.01	1.01	1.09
1921-25	1.10	1.04	1.05	1.14
1926-30	1.10	1.10	1.07	1.19
Females $\overset{o}{e}_0$				
1911-15	1.00	.97	.99	1.09
1916-20	1.03	1.01	1.02	1.14
1921-25	1.08	1.11	1.06	1.15
1926-30	1.14	1.12	1.09	1.26
Males $\overset{o}{e}_{15}$				
1911-15	1.00	.99	1.00	1.01
1916-20	1.01	.99	1.00	1.03
1921-25	1.06	1.03	1.05	1.10
1926-30	1.04	1.04	1.05	1.07
Females $\overset{o}{e}_{15}$				
1911-15	1.00	.99	.98	1.04
1916-20	1.02	1.01	1.02	1.05
1921-25	1.06	1.06	1.05	1.11
1926-30	1.07	1.07	1.05	1.14

Table 3.3 Probability of dying between 15–64 and 15–74 in the shale activity areas 1911–30 (using smoothed life table data).

	High Shale	Low Shale	No Shale Industrial	No Shale Rural
Males 15-64				
1911-15	.427	.432	.433	.403
1916-20	.409	.451	.432	.382
1921-25	.345	.386	.382	.288
1926-30	.363	.361	.374	.317
Females 15-64				
1911-15	.429	.440	.449	.364
1916-20	.413	.419	.400	.344
1921-25	.356	.352	.372	.315
1926-30	.320	.330	.351	.238
Males 15-74				
1911-15	.696	.697	.697	.700
1916-20	.680	.732	.707	.677
1921-25	.613	.652	.651	.528
1926-30	.649	.643	.643	.617
Females 15-74				
1911-15	.679	.685	.702	.627
1916-20	.666	.672	.645	.613
1921-25	.598	.610	.619	.553
1926-30	.572	.578	.598	.487

Table 3.4 Ratios of the probability of dying 15–64 for shale activity areas and five-year periods relative to that for high shale 1911–15.

	High Shale	Low Shale	No Shale Industrial	No Shale Rural
Males				
1911-15	1.00	1.01	1.01	.94
1916-20	.96	1.06	1.01	.90
1921-25	.81	.90	.90	.67
1926-30	.85	.85	.88	.74
Females				
1911-15	1.00	1.03	1.05	.85
1916-20	.96	.98	.93	.79
1921-25	.83	.82	.87	.73
1926-30	.75	.77	.82	.55

Table 3.5 All cause mortality 1911–31: Estimated relative risks (e.r.r.) and associated 95% confidence intervals of shale activity areas, according to 3-group and to 4-group classification (see text 2.3.3), from log-linear modelling of rates (see text 2.7.3) separately for males and females all ages and at ages 15–74 years: internal classifications.

	males			females		
Comparison	e.r.r	95% limits		e.r.r	95% limits	
All Ages						
*Coal:Shale	1.07	1.03	1.11	1.06	1.02	1.10
*Shale:Rural	1.05	1.00	1.11	1.06	1.01	1.12
*Coal:Rural	1.12	1.07	1.18	1.12	1.07	1.18
Low:High Shale	1.05	1.00	1.10	1.01	0.97	1.06
**NSI:High Shale	1.05	1.01	1.10	1.05	1.00	1.10
**NSI:Low Shale	1.00	0.95	1.04	1.04	0.99	1.09
High Shale:Rural	1.15	1.06	1.25	1.24	1.14	1.35
Low Shale:Rural	1.20	1.10	1.30	1.25	1.14	1.36
**NSI:Rural	1.20	1.10	1.31	1.30	1.20	1.42
15-74						
*Coal:Shale	1.03	0.98	1.09	1.00	0.95	1.06
*Shale:Rural	1.05	0.98	1.12	1.08	1.00	1.15
*Coal:Rural	1.09	1.02	1.17	1.08	1.01	1.16
Low:High Shale	1.06	1.00	1.13	0.99	0.92	1.05
**NSI:High Shale	1.00	0.95	1.06	1.02	0.96	1.09
**NSI:Low Shale	0.95	0.89	1.01	1.04	0.97	1.11
High Shale:Rural	1.13	1.02	1.27	1.21	1.08	1.35
Low Shale:Rural	1.20	1.08	1.35	1.20	1.07	1.34
**NSI:Rural	1.16	1.04	1.30	1.25	1.12	1.39

* Coal (or Industrial); Rural (or No Shale).

** NSI = No Shale, Industrial.

Table 3.6 All-cause mortality 1911-31: Estimated relative risks (e.r.r.) and associated 95% confidence intervals, as in Table 3.5, but relative to the population of Scotland.

Comparison	males e.r.r	95% C.I.		females e.r.r	95% C.I.	
All Ages						
Coal*	0.92	0.89	0.94	0.98	0.96	1.01
Rural*	0.83	0.80	0.87	0.88	0.85	0.92
Shale*	0.86	0.84	0.89	0.94	0.91	0.96
High Shale	0.86	0.83	0.89	0.94	0.91	0.97
Low Shale	0.91	0.88	0.94	0.95	0.92	0.99
NSI*	0.90	0.87	0.93	0.98	0.95	1.01
Rural	0.76	0.70	0.82	0.76	0.70	0.82
15-74						
Coal	0.89	0.85	0.92	0.99	0.95	1.03
Rural	0.83	0.79	0.88	0.92	0.87	0.97
Shale	0.86	0.83	0.89	0.99	0.95	1.03
High Shale	0.86	0.83	0.90	0.99	0.95	1.03
Low Shale	0.91	0.87	0.95	0.97	0.93	1.02
NSI	0.86	0.82	0.89	1.01	0.96	1.05
Rural	0.76	0.68	0.84	0.81	0.73	0.90

* See notes to Table 3.5.

Table 3.7 Ratio of male to female probabilities of dying at ages 15-64 and 15-74, for various periods 1911-31. (Ratios derived from Rable 3.3).

	High Shale	Low Shale	No shale Industrial	No shale Rural
		Probability of dying 15-64		
1911-15	1.00	.98	.96	1.11
1916-20	.99	1.08	1.08	1.12
1921-25	.97	1.10	1.03	.91
1926-30	1.13	1.09	1.07	1.33
		Probability of dying 15-74		
1911-15	1.03	1.02	.99	1.12
1916-20	1.02	1.09	1.10	1.10
1921-25	1.03	1.07	1.05	.95
1926-30	1.13	1.13	1.08	1.27

Table 3.8 All cause mortality 1963(53)–81: Estimated relative risk (e.r.r.) and associated 95% confidence interval from comparisons of mortality in the Shale area with, respectively, that in all Scotland, Fife and the No Shale Industrial area.

Comparison	All Cause (1963-81)			All Non-Cancer (1963-81)			All Cancer (1953-81)		
	e.r.r	95% C.I.		e.r.r	95% C.I.		e.r.r	95% C.I.	
Males: all ages									
Scotland	1.02	0.99	1.05	1.02	0.99	1.05	0.99	0.94	1.04
Fife	1.08	1.04	1.11	1.07	1.04	1.11	1.08	1.02	1.15
Industrial	1.06	1.02	1.10	1.05	1.00	1.09	1.08	1.01	1.16
Males: 15-74									
Scotland	1.01	0.97	1.04	1.01	0.97	1.05	0.96	0.91	1.06
Fife	1.07	1.03	1.11	1.08	1.03	1.13	1.06	0.99	1.13
Industrial	1.05	1.00	1.10	1.05	0.99	1.10	1.06	0.97	1.15
Females: all ages									
Scotland	1.04	1.01	1.07	1.04	1.01	1.08	1.01	0.95	1.07
Fife	1.07	1.04	1.11	1.07	1.03	1.11	1.07	1.00	1.14
Industrial	1.00	0.96	1.04	0.99	0.94	1.03	1.03	0.95	1.12
Females: 15-74									
Scotland	1.02	0.98	1.07	1.02	0.97	1.08	1.03	0.96	1.10
Fife	1.07	1.02	1.12	1.06	1.01	1.12	1.09	1.01	1.18
Industrial	0.98	0.92	1.03	0.95	0.89	1.01	1.05	0.96	1.15

Table 3.9 Numbers of deaths from non-malignant causes in the shale and comparison areas, 1963-81.

Cause	Shale	No Shale Industrial	Fife	Scotland
Males				
benign neoplasms	10	19	53	1017
TB*	5	17	95	2915
endocrine/metabolic	48	75	384	5685
blood	11	12	87	1320
psychoses	19	16	75	1289
neuro-sensory	35	51	303	6160
IHD*	1494	1989	12425	191948
cerebrovascular	549	852	5187	73701
other circulatory	374	494	3043	48473
bronchitis/emphysema	247	351	2111	34693
industrial	25	112	283	2443
other respiratory	240	401	1810	34011
digestive	118	160	851	16305
genito-urinary	65	85	497	8812
musculo-skeletal	13	8	84	1220
ill-defined	29	44	153	2576
other internal	165	219	911	17274
external	304	343	1930	34153
Females				
benign neoplasms	5	12	49	1177
TB	6	7	45	1390
endocrine/metabolic	84	143	589	10007
blood	19	21	140	2394
psychoses	23	22	147	2803
neuro-sensory	34	66	323	6760
IHD	877	1343	9167	149374
cerebrovascular	733	1123	7437	113668
other circulatory	462	625	4359	71079
bronchitis/emphysema	88	122	687	13591
industrial	0	0	2	57
other respiratory	256	358	1983	37908
digestive	97	176	945	17109
genito-urinary	65	92	524	8764
musculo-skeletal	16	18	171	3158
ill-defined	20	33	162	3248
other internal	167	201	771	13995
external	178	221	1480	23623

* TB - Tuberculosis

* IHD - Ischaemic Heart Disease

Table 3.10 Mortality from non-malignant causes: SMRs in the Shale area using Scotland as a standard; for various (usually 5-year) periods 1963-81.

	63-67	68-72	73-78	79-81
Males				
other benign neoplasms	-	110	154	175
tuberculosis	13*	16*	53	-
endocrine/metabolic	76	88	121	134
blood	141	88	142	53
psychoses	304	234	263	78
neurosensory	76	39*	80	74
ischaemic heart disease	110	100	106	106
cerebrovascular disease	123	97	104	97
other circulatory	114	98	119	101
bronchitis/emphysema	91	101	111	93
industrial diseases	152	131	217	56
other respiratory	120	88	89	92
digestive	86	116	97	80
genito-urinary	114	142	88	47*
musculo-skeletal	96	240	124	121
ill defined	180	89	72	172
other internal	83	83	104	74
all external	119	94	81	95
Females				
other benign neoplasms	-	104	72	47
tuberculosis	90	106	-	-
endocrine/metabolic	99	88	160*	170
blood	186	178	107	37
psychoses	229	271	46	167
neurosensory	58	111	59*	50*
Ischaemic heart disease	113	84*	93	110
cerebrovascular disease	118	109	110	112
other circulatory	112	141*	97	97
bronchitis/emphysema	99	90	120	97
other respiratory	81	129	111	113
digestive	96	98	90	69
genito-urinary	129	86	108	165
musculo-skeletal	27*	134	80	68
ill defined	110	188	31*	91
other internal	110	119	119	110
all external	125	89	100	100

NOTES: * SMR statistically significant at 5% level.
- Zero deaths in the Shale area (statistical significance not estimated).

Table 3.11 Mortality from non-malignant causes; SMRs in the 'No Shale Industrial' area, using Scotland as a standard; by sex; for various (usually 5-year) periods 1963-81.

	63-67	68-72	73-78	79-81
Males				
other benign neoplasms	268	113	87	209
tuberculosis	62	11*	101	-
endocrine/metabolic	102	129	102	149
blood	22*	116	77	164
psychoses	191	89	153	55
neurosensory	41*	108	66	72
ischaemic heart disease	90*	90*	98	99
cerebrovascular disease	101	105	115*	112
other circulatory	89	100	103	82
bronchitis/emphysema	65*	96	108	123
industrial diseases	441*	469*	450*	289
other respiratory	125	105	98	113
digestive	98	59*	103	86
genito-urinary	81	92	93	101
musculo-skeletal	59	31*	86	47
ill defined	192*	258*	13	157
other internal	89	92	123	96
all external	103	83	75*	75*
Females				
other benign neoplasms	72	107	112	114
tuberculosis	18*	72	84	-
endocrine/metabolic	131	147	168*	169*
blood	65	137	77	145
psychoses	104	65	74	136
neurosensory	100	89	111	85
ischaemic heart disease	99	96	105	106
cerebrovascular disease	108	116*	114*	123*
other circulatory	111	114	95	84
bronchitis/emphysema	66*	68*	128	152
other respiratory	114	102	115	95
digestive	126	120	88	119
genito-urinary	103	132	109	111
muscular/skeletal	83	59	48*	70
ill defined	164	125	88	74
other internal	124	119	126	105
all external	85	114	93	82

NOTES: * SMR statistically significant at 5% level.
– Zero deaths in the Shale area (statistical significance not estimated).

Table 3.12 Mortality from non-malignant causes, 1963-81. Estimated relative risks (e.r.r.) and associated 95% confidence intervals, from analyses of mortality, by sex, in the Shale area relative to all Scotland.

Cause	males e.r.r	males 95%	C.I.	females e.r.r	females 95%	C.I.
Benign neoplasms	1.34	0.72	2.50	0.62	0.23	1.66
Tuberculosis	0.27	0.11	0.65	0.69	0.31	1.54
Endocrine/metabolic	1.08	0.81	1.44	1.34	1.07	1.66
Blood	1.07	0.55	2.05	1.40	0.88	2.22
Psychoses	2.13	1.35	3.34	1.43	0.95	2.15
Neuro-sensory	0.67	0.48	0.94	0.69	0.49	0.96
Ischaemic heart disease	1.05	1.00	1.11	0.97	0.91	1.04
Cerebrovascular	1.06	0.97	1.15	1.10	1.03	1.19
Other circulatory	1.09	0.98	1.20	1.13	1.03	1.23
Bronchitis/emphysema	1.01	0.89	1.14	1.04	0.84	1.29
Industrial	1.51	1.02	2.24	-	-	-
Other respiratory	0.93	0.82	1.06	1.08	0.96	1.22
Digestive	0.94	0.79	1.13	0.86	0.71	1.06
Genito-urinary	1.03	0.81	1.32	1.18	0.93	1.51
Musculo-skeletal	1.50	0.87	2.59	0.81	0.50	1.33
Ill-defined	1.07	0.62	1.85	0.85	0.48	1.50
Other internal	0.87	0.75	1.01	1.14	0.98	1.32
External	0.95	0.84	1.06	1.01	0.87	1.18

Table 3.13 Mortality from non-malignant causes, 1963-81. Estimated relative risks (e.r.r.) and associated 95% confidence intervals, from analyses of mortality, by sex, in the Shale area relative to Fife.

Cause	males e.r.r	males 95%	C.I.	females e.r.r	females 95%	C.I.
Benign neoplasms	1.59	0.81	3.13	0.83	0.30	2.32
Tuberculosis	0.51	0.21	1.25	1.29	0.55	3.02
Endocrine/metabolic	1.03	0.76	1.39	1.39	1.10	1.75
Blood	0.99	0.50	1.97	1.46	0.89	2.39
Psychoses	2.49	1.50	4.13	1.66	1.07	2.58
Neuro-sensory	0.85	0.60	1.21	0.86	0.61	1.23
Ischaemic heart disease	1.06	1.00	1.12	0.97	0.91	1.04
Cerebrovascular	0.99	0.90	1.08	1.03	0.96	1.12
Other circulatory	1.15	1.03	1.28	1.15	1.05	1.27
Bronchitis/emphysema	1.08	0.95	1.23	1.25	1.00	1.57
Industrial	0.85	0.57	1.29	-	-	-
Other respiratory	1.17	1.02	1.34	1.28	1.13	1.46
Digestive	1.19	0.98	1.44	0.97	0.79	1.20
Genito-urinary	1.19	0.92	1.54	1.24	0.96	1.61
Musculo-skeletal	1.36	0.76	2.44	0.88	0.53	1.48
Ill-defined	1.29	0.73	2.31	0.99	0.55	1.79
Other internal	1.05	0.89	1.24	1.30	1.10	1.54
External	1.08	0.95	1.22	1.01	0.86	1.18

Table 3.14 Mortality from non-malignant causes, 1963-81. Estimated relative risks (e.r.r.) and associated 95% confidence intervals, from analyses of mortality, by sex, in the Shale area relative to 'No Shale Industrial'.

Cause	males e.r.r	males 95%	C.I.	females e.r.r	females 95%	C.I.
Benign neoplasms	0.82	0.38	1.79	0.57	0.18	1.82
Tuberculosis	0.45	0.16	1.21	1.30	0.44	3.87
Endocrine/metabolic	0.86	0.56	1.33	0.84	0.64	1.11
Blood	1.21	0.50	2.91	1.37	0.72	2.59
Psychoses	1.85	0.95	3.59	1.56	0.87	2.80
Neuro-sensory	0.94	0.61	1.44	0.72	0.47	1.09
Ischaemic heart disease	1.12	1.04	1.19	0.96	0.88	1.04
Cerebrovascular	0.98	0.88	1.09	0.97	0.88	1.06
Other circulatory	1.15	1.01	1.32	1.11	0.99	1.25
Bronchitis/emphysema	1.07	0.91	1.26	1.04	0.79	1.37
Industrial	0.35	0.23	0.54	-	-	-
Other respiratory	0.89	0.76	1.04	1.03	0.88	1.21
Digestive	1.08	0.85	1.38	0.80	0.62	1.03
Genito-urinary	1.16	0.84	1.61	1.02	0.74	1.40
Musculo-skeletal	2.45	1.01	5.91	1.43	0.72	2.85
Ill-defined	0.56	0.30	1.05	0.70	0.35	1.37
Other internal	0.86	0.70	1.05	0.96	0.78	1.18
External	1.16	0.99	1.35	1.07	0.88	1.31

Table 3.15 Numbers of deaths from malignant causes (1953-81) in the shale and comparison areas.

Site	Shale	No Shale Industrial	Fife	Scotland
Males				
Mouth	24	33	218	3651
Stomach	140	245	1270	22524
Large intestine	92	119	769	14729
Rectum	54	73	532	8961
Liver	6	7	69	1365
Other digestive	131	191	1010	16694
Respiratory	508	700	4138	73793
Skin	9	8	81	1159
Breast	3	3	11	187
Bone & connective	19	37	128	2430
Cervix	0	0	0	0
Bladder	55	76	490	6989
Kidney	31	43	208	3467
Other genito-urinary	102	100	840	12496
Lymphatic	83	119	731	10624
Other & unknown	75	88	507	8457
Females				
Mouth	12	21	122	2157
Stomach	92	154	1114	19109
Large intestine	116	182	1108	21006
Rectum	27	67	440	7464
Liver	6	13	49	882
Other digestive	117	171	979	16727
Respiratory	100	131	856	17920
Skin	5	5	45	903
Breast	203	268	1757	29586
Bone & connective tissue	20	23	144	2289
Cervix	46	65	443	6782
Bladder	33	32	191	3515
Kidney	16	22	131	2329
Other genito-urinary	99	136	956	15732
Lymphatic	75	108	568	9405
Other & unknown	77	96	553	8926

Table 3.16 Mortality from malignant causes: SMRs in the Shale area, using Scotland as a standard; by sex; for various (usually 5-year) periods 1953-81.

	53-57	58-62	63-67	68-72	73-78	79-81
Males						
Mouth	35	117	181	112	42	141
Stomach	99	108	82	74	102	57*
Large intestine	79	90	71	93	102	106
Rectum	48*	82	82	95	91	133
Liver	222	-	-	-	89	-
Other digestive	83	122	117	112	107	131
Respiratory	90	70	92	101	99	114
Skin	59	206	-	179	187	-
Bone & connective tissue	126	35	78	66	175	90
Bladder	169	73	152	129	71	120
Kidney	126	107	78	115	143	162
Other genito-urinary	108	116	164	127	112	83
Lymphatic	161	122	176*	44*	67	105
Other unknown	115	63	165	131	109	100
Females						
Mouth	101	100	-	94	108	161
Stomach	70	81	121	68	72	125
Large intestine	79	110	104	96	96	89
Rectum	121	63	43*	51	73	16*
Liver	-	-	-	106	184	369
Other digestive	82	135	123	89	119	150
Respiratory	68	74	35*	54*	115	95
Skin	268	-	130	110	83	-
Breast	79	109	129	96	112	98
Bone & connective tissue	440	143	94	72	25*	120
Cervix	62	60	123	62	131	175
Bladder	144	200	193	273	68	133
Kidney	119	115	44	174	102	91
Other genito-urinary	101	119	99	86	76	139
Lymphatic	212*	51	180	111	92	118
Other unknown	46	175	162	147	129	96

NOTES: * SMR statistically significant at 5% level.
- Zero deaths in the Shale area (statistical significance not estimated).

Table 3.17 Mortality from malignant causes: SMRs in the 'No Shale Industrial' area, using Scotland as a standard; by sex; for various (usually 5-year) periods 1953-81.

	53-57	58-62	63-67	68-72	73-78	79-81
Males						
Mouth	35*	139	32*	162	58	164
Stomach	106	114	111	84	104	99
Large intestine	105	112	68	71	70*	24*
Rectum	71	79	76	61	116	40*
Liver	49	86	37	-	31*	110
Other digestive	110	110	108	97	86	149
Respiratory	84	62*	86	100	93	89
Skin	40	136	107	57	42	-
Bone & connective tissue	281*	87	95	45	171	117
Bladder	124	67	104	95	124	97
Kidney	80	50	127	134	135	146
Other genito-urinary	45*	87	67	82	70	126
Lymphatic	81	127	69	103	97	143
Other unknown	83	77	143	98	81	86
Females						
Mouth	95	94	154	92	128	84
Stomach	87	129	106	88	69*	89
Large intestine	94	127	110	89	89	97
Rectum	88	129	53*	83	135	114
Liver	-	150	350	141	68	294
Other digestive	104	131	138	115	104	97
Respiratory	79	52*	68	83	77	81
Skin	85	79	80	-	117	-
Breast	100	95	66*	99	98	111
Bone & connective tissue	61	116	114	123	79	142
Cervix	96	46*	109	91	140	88
Bladder	61	50	118	123	108	122
Kidney	149	106	107	92	74	107
Other genito-urinary	109	52*	101	113	90	82
Lymphatic	141	156	130	116	118	57
Other unknown	85	75	90	76	151*	132

NOTES: * SMR statistically significant at 5% level.
– Zero deaths in the Shale area (statistical significance not estimated).

Table 3.18 Mortality from malignant causes, 1953-81: Estimated relative risks (e.r.r.) and associated 95% confidence intervals, from analyses of mortality, by sex, in the Shale area relative to all Scotland.

	males			females		
Site	e.r.r	95%	C.I.	e.r.r	95%	C.I.
Mouth	0.97	0.65	1.46	0.83	0.45	1.55
Stomach	0.90	0.76	1.06	0.86	0.70	1.06
Large intestine	0.90	0.74	1.11	0.95	0.79	1.14
Rectum	0.88	0.67	1.14	0.64	0.44	0.93
Liver	0.67	0.30	1.49	1.23	0.55	2.74
Other digestive	1.10	0.93	1.31	1.17	0.97	1.40
Respiratory	0.95	0.87	1.03	0.84	0.69	1.02
Skin	1.28	0.67	2.48	1.14	0.47	2.74
Breast	3.07	0.98	9.63	1.05	0.91	1.20
Bone & connective tissue	1.04	0.66	1.63	1.29	0.83	2.01
Cervix	-	-	-	1.02	0.76	1.36
Bladder	1.13	0.86	1.47	1.57	1.11	2.21
Kidney	1.23	0.86	1.77	1.07	0.64	1.78
Other genito-urinary	1.19	0.98	1.45	0.99	0.81	1.20
Lymphatic	1.01	0.82	1.26	1.18	0.94	1.48
Other unknown	1.12	0.89	1.40	1.25	1.00	1.56

Table 3.19 Mortality from malignant causes, 1953-81: Estimated relative risks (e.r.r.) and associated 95% confidence intervals, from analyses of mortality, by sex, in the Shale area relative to Fife.

	males			females		
Site	e.r.r	95%	C.I.	e.r.r	95%	C.I.
Mouth	1.05	0.69	1.60	0.88	0.46	1.67
Stomach	1.02	0.86	1.22	0.89	0.72	1.10
Large intestine	1.11	0.90	1.38	1.10	0.91	1.33
Rectum	0.94	0.71	1.25	0.66	0.45	0.98
Liver	0.83	0.36	1.91	1.37	0.58	3.20
Other digestive	1.17	0.97	1.40	1.21	1.00	1.47
Respiratory	1.09	0.99	1.19	1.06	0.86	1.30
Skin	1.19	0.60	2.37	1.36	0.54	3.45
Breast	2.44	0.68	8.83	1.08	0.93	1.25
Bone & connective tissue	1.27	0.78	2.05	1.26	0.79	2.02
Cervix	-	-	-	0.92	0.68	1.25
Bladder	1.05	0.80	1.39	1.77	1.22	2.57
Kidney	1.29	0.88	1.88	1.17	0.68	2.00
Other genito-urinary	1.16	0.94	1.42	0.99	0.80	1.22
Lymphatic	0.94	0.75	1.18	1.19	0.94	1.52
Other unknown	1.18	0.93	1.51	1.24	0.98	1.58

Table 3.20 Mortality from malignant causes, 1953-81: Estimated relative risks (e.r.r.) and associated 95% confidence intervals, from analyses of mortality, by sex, in the Shale area relative to 'No Shale Industrial'.

	males			females		
Site	e.r.r	95%	C.I.	e.r.r	95%	C.I.
Mouth	1.09	0.64	1.84	0.72	0.34	1.52
Stomach	0.87	0.71	1.07	0.91	0.70	1.18
Large intestine	1.17	0.89	1.54	0.96	0.76	1.22
Rectum	1.12	0.78	1.59	0.60	0.38	0.94
Liver	1.28	0.43	3.81	0.67	0.26	1.78
Other digestive	1.03	0.82	1.28	1.02	0.80	1.29
Respiratory	1.08	0.97	1.21	1.10	0.85	1.43
Skin	1.73	0.67	4.49	1.94	0.52	7.22
Breast	1.51	0.31	7.43	1.10	0.91	1.32
Bone & connective tissue	0.73	0.42	1.27	1.28	0.70	2.33
Cervix	-	-	-	1.02	0.70	1.49
Bladder	1.09	0.77	1.55	1.53	0.94	2.49
Kidney	1.09	0.68	1.74	1.02	0.53	1.97
Other genito-urinary	1.55	1.18	2.05	1.08	0.83	1.40
Lymphatic	1.02	0.77	1.35	1.02	0.76	1.37
Other unknown	1.23	0.91	1.68	1.14	0.85	1.54

Table 3.21 Number and percent cases and controls, by age at death.

Group	<50	50-54	55-59	Age at Death 60-64	65-69	70-74	75-79	80-84	85+
Males									
Other genito-	10	1	6	17	36	44	62	52	27
urinary	3.9%	0.4%	2.4%	6.7%	14.1%	17.3%	24.3%	20.4%	10.6%
Skin	0	0	2	2	4	5	2	1	5
	0.0%	0.0%	9.5%	9.5%	19.0%	23.8%	9.5%	4.8%	23.8%
Controls	360	295	433	546	638	560	414	219	100
	10.1%	8.3%	12.1%	15.3%	17.9%	15.7%	11.6%	6.1%	2.8%
Females									
Bladder	4	4	6	10	14	16	7	10	3
	5.4%	5.4%	8.1%	13.5%	18.9%	21.6%	9.4%	13.5%	4.1%
Skin	2	0	0	1	3	1	2	2	2
	15.4%	0.0%	0.0%	7.7%	23.1%	7.7%	15.4%	15.4%	15.4%
Controls	415	241	303	404	395	418	326	219	164
	14.4%	8.4%	10.5%	14.0%	13.7%	14.5%	11.3%	7.6%	5.7%

Table 3.22 Number and percent cases and controls, by year of death.

Group	53-54	55-59	60-64	Year of Death 65-69	70-74	75-79	80-81
Males							
Other genito-	9	37	36	45	48	54	26
urinary	3.5%	14.5%	14.1%	17.6%	18.8%	21.1%	10.2%
Skin	2	6	1	4	4	4	0
	9.5%	28.6%	4.8%	19.0%	19.0%	19.0%	0.0%
Controls	169	477	485	620	701	765	348
	4.7%	13.4%	13.6%	17.4%	19.7%	21.5%	9.8%
Females							
Bladder	3	6	10	15	14	16	10
	4.1%	8.1%	13.5%	20.3%	18.9%	21.6%	13.5%
Skin	0	4	1	2	1	4	1
	0.0%	30.8%	7.7%	15.4%	7.7%	30.8%	7.7%
Controls	144	359	448	443	529	667	295
	5.0%	12.4%	15.5%	15.4%	18.3%	23.1%	10.2%

Table 3.23 Number and percent cases and controls, by shale activity area.

Cause	Male Shale	Male Industrial	Male Rural	Male Total	Female Shale	Female Industrial	Female Rural	Female Total
Bladder					33	32	9	74
					44.6%	43.2%	12.2%	100%
Other genito-	102	100	53	255				
urinary	40.0%	39.2%	20.8%	100%				
Skin	9	8	4	21	5	5	3	13
	42.9%	38.1%	19.0%	100%	38.5%	38.5%	23.1%	100%
Control	1165	1658	742	3565	907	1320	658	2885
	32.7%	46.5%	20.8%	100%	31.4%	45.8%	22.8%	100%
Total	1276	1766	799	3841	945	1357	670	2972

Table 3.24 Number (%) of cases and controls, by civil parish (CP) of residence, at death. (Abbreviated CP names; full names in Table A2.2.

Group	Currie & Ratho	Kirkltn MidLoth	Dalmeny	Linlith -gow	Kirk-newton	Uphall	Living-ston	Mid-Calder
	Civil Parish at Death							
Shale Area	NSR	NSR	NSR	NSR	NSR	Shale	Shale	Shale
Males:								
Other genito-urinary	20 (7.8%)	4 (1.6%)	14 (5.5%)	8 (3.1%)	7 (2.7%)	27 (10.6%)	18 (7.1%)	16 (6.3%)
Skin	0 (0.0%)	0 (0.0%)	1 (4.8%)	1 (4.8%)	2 (9.5%)	3 (14.3%)	1 (4.8%)	2 (9.5%)
Controls	217 (6.1%)	46 (1.3%)	144 (4.0%)	238 (6.7%)	97 (2.7%)	386 (10.8%)	246 (6.9%)	189 (5.3%)
Females:								
Bladder	4 (5.4%)	1 (1.4%)	3 (4.1%)	1 (1.4%)	1 (1.4%)	14 (18.9%)	4 (5.4%)	4 (5.4%)
Skin	2 (15.4%)	0 (0.0%)	1 (7.7%)	0 (0.0%)	0 (0.0%)	1 (7.7%)	0 (0.0%)	3 (23.1%)
Controls	242 (8.4%)	46 (1.6%)	128 (4.4%)	162 (5.6%)	80 (2.8%)	337 (11.7%)	161 (5.6%)	166 (5.8%)

Group	West Calder	Kirkltn WestLth	Aber-corn	Bath-gate	Torph-ican	Whit-burn	Boness& Carridn	Total
	Civil Parish at Death							
Shale area	Shale	Shale	Shale	NSI	NSI	NSI	NSI	
Males:								
Other genito-urinary	26 (10.2%)	13 (5.1%)	2 (0.8%)	51 (20.0%)	1 (0.4%)	23 (9.0%)	25 (9.8%)	255 (100%)
Skin	1 (4.8%)	2 (9.5%)	0 (0.0%)	4 (19.0%)	0 (0.0%)	2 (9.5%)	2 (9.5%)	21 (100%)
Controls	203 (5.7%)	126 (3.5%)	15 (0.4%)	719 (20.2%)	38 (1.1%)	458 (12.8%)	443 (12.4%)	3565 (100%)
Females:								
Bladder	7 (9.5%)	3 (4.1%)	1 (1.4%)	20 (27.0%)	1 (1.4%)	5 (6.8%)	6 (8.1%)	74 (100%)
Skin	0 (0.0%)	1 (7.7%)	0 (0.0%)	1 (7.7%)	0 (0.0%)	3 (23.1%)	1 (7.7%)	13 (100%)
Controls	140 (9%)	87 (3.0%)	16 (0.6%)	598 (20.7%)	37 (1.3%)	342 (11.9%)	343 (11.9%)	2885 (100%)

Table 3.25 Number and percent of cases and controls, by occupation.

Year of coding revision		Occupational Group: Coal-mining	Probable Shale	Possible Shale	Other
1950	Other genito-urinary	8	10	0	19
		22%	27%	0.0%	51%
	Skin	1	1	0	3
		20%	20%	0.0%	60%
	Control	95	61	24	364
		17%	11%	4%	67%
1960	Other genito-urinary	9	11	2	68
		10%	12%	2%	76%
	Skin	2	3	0	3
		25%	38%	0.0%	38%
	Control	238	94	28	847
		20%	8%	2%	70%
1970	Other genito-urinary	2	3	0	79
		20%	3%	0.0%	77%
	Skin	0	2	0	6
		0.0%	25%	0.0%	75%
	Control	196	90	33	1147
		13%	6%	2%	78%
1980	Other genito-urinary	2	1	0	23
		8%	4%	0.0%	88%
	Skin	0	0	0	0
		0.0%	0.0%	0.0%	0.0%
	Control	41	11	2	294
		12%	3%	1%	84%
Overall	Other genito-urinary	39	25	2	189
		15%	10%	1%	74%
	Skin	3	6	0	12
		14%	29%	0.0%	57%
	Control	570	256	87	2652
		14%	7%	2%	74%

Table 3.26 Results from logistic regression of the probability of dying from 'other genito-urinary' cancer (males).

Model 1: Effect of age, year of death and occupation at death.

Variable	1953-69 Co-efficient	1953-69 t-value	1953-81 Co-efficient	1953-81 t-value
CONSTANT	-7.800	-5.31	-7.408	-9.70
AGE (YRS)	0.081	8.19	0.077	10.91
YEAR OF DEATH	-0.007	-0.36	-0.008	-0.99
OCCUPATION: (1)				
COAL	-0.067	-0.18	-0.014	-0.05
POSSIBLE SHALE	-7.575	-0.23	-7.607	-0.23
PROBABLE SHALE	0.860	2.24	0.235	0.99

Model 2: Effect of age, year of death, occupation at death and area.

Variable	1953-69 Co-efficient	1953-69 t-value	1953-81 Co-efficient	1953-81 t-value
CONSTANT	-7.648	-5.16	-7.414	-9.56
AGE (YRS)	0.082	8.19	0.077	10.92
YEAR OF DEATH	-0.010	-0.48	-0.009	-1.04
OCCUPATION: (1)				
COAL	0.062	0.16	0.019	0.06
POSSIBLE SHALE	-7.709	-0.24	-7.679	-0.24
PROBABLE SHALE	0.590	1.49	0.190	0.79
AREA: (2)				
INDUSTRIAL	-0.373	-1.39	-0.131	-0.72
SHALE	0.353	1.36	0.242	1.33

(1) compared to non-shale.
(2) compared to rural.

APPENDIX 1

Detailed Shale Production and Throughput Data

A1.1 Estimation of Shale Production and Throughput Prior to 1919

For the period prior to 1919 production or throughput data are only available for the shale field as a whole. However, for 1911-20 there exist nearly complete data on the numbers of mines operating in each area and complete data on total oilworks. Before 1911 much information is lacking. The data on working mines come from a variety of sources including maps (Table A2.1A), interviews with old people (Randall, 1990), documents on the shale mining industry from Archives of British Petroleum, Inspector of Mines reports, 1890-1908. From these a rough guide as to the intensity of the industry can be gathered from 'mine-years' and 'oil work years' worked per CP, where each mine-year worked has a weight of one irrespective of the size of the mine. For the period 1911-18 the rankings are shown in Table A1.1.

A1.2 Estimation of Annual Shale Production - 1919-1962

In order to estimate the level of shale production and throughput by civil parish, data were obtained for each mine and oilworks located in the shale area. For calculation of shale production, monthly returns of shale produced by each mine and pit were available for 1919-62 (BP Archives, AR0230-AR0264). In general, the annual production per mine was estimated from two monthly totals which were summed and the sum multiplied by six to give a yearly figure. Where less than a full year was worked the multiplication factor was reduced accordingly. This method of estimation was used since most mines had fairly constant production levels throughout the year. In some cases approximations were necessary where some of the data were missing. The precise methods used to calculate production for each year are summarised in Table A1.2.

A1.3 Estimation of Annual Throughput in Oil Works - 1920-62

For 1920-39 annual throughput figures for each works were available directly from records (BP Archives, AR0651). For 1940-62 the throughput was estimated from mine production figures using information about which mines sent shale to which oilworks (BP Archives, ARO230-264). The annual totals per mine were calculated as above. When an oilworks shut down but the exact month of closure is unknown it has been allocated throughput for the whole year. In some cases it was necessary to make some assumptions as to where new mines would send their shale, or where mines sent shale after a particular works had shut.

These estimates of throughput assume that all shale was processed immediately; this is not strictly the case but is unlikely to seriously affect the classification of Civil Parish shale activity.

A1.4 Classification of Civil Parishes

For each civil parish, annually, there are two directly calculated measures of shale activity - production of shale and actual throughput. In addition, several of the oilworks are located very close to considerable populations in a neighbouring parish. As the principal health effect of an oilworks on the population is probably through emissions of gases, smoke and dust, it is reasonable to allocate its throughput to both the CPs concerned. In these cases the throughput was divided equally between the two parishes. This measure is called the 'effective throughput'. Table A1.3 shows all the oilworks, their parish of location and adjacent parishes deemed to be affected by them. All three measures of shale activity are measured to the nearest 1000 tons and those for average annual production and effective throughput are listed for five-year periods for each civil parish in Table A1.4.

Table A1.5 classifies these data into 'High' and 'Low' categories and shows production and effective throughput by decade of occurrence and lagged by 20 years. This was done since any effect that shale has on the health and mortality of a population is likely to be long term rather than short term. Thus 10-year periods are more applicable than 5-year ones. In addition, shale mining and the processing of shale through the oilworks are each likely to have different effects on health. The former might operate through physical contact or the water supply, whereas the latter is more likely to operate through atmospheric factors and air pollution. Shale activity status of the area 20 years previously is probably more relevant than current status for the investigation of links between shale activity and cancer mortality.

In the final classification of the civil parishes, a few non-quantifiable factors were also taken into account as follows :

(a) Bathgate: For the earlier part of the period both production and throughput levels were quite high. However, the shale industry in this civil parish is right in the easternmost corner - over two miles from the population centre. The labour force for this industrial site came from a village (Livingston Station now called Deans) just over the boundary, in Livingston CP. Thus the shale industry itself had little or no effect on the majority of Bathgate CP's population. Bathgate burgh people think of themselves as from a coal mining rather than a shale mining area.

(b) Dalmeny: Although the shale industry stopped operating in the early 1920s in Dalmeny, a good many men from the village were transferred to Duddingston and Whitequarries mines and until the 1950s the village was still part of the shale mining community.

(c) Mid Calder: Not apparently with a high shale production or consumption activity level, this civil parish contained Pumpherston Refinery which worked throughout the period refining the shale oil.

A1.5 Classification of Shale Areas - 1911-31

Two different classifications were used - based partly on the above 'objective' information and partly from supplementary information gleaned from interviews with old people from the area. One of the aims of the classification was to try and create relatively homogeneous areas both with respect to shale activity and other activities - such as coalmining or farming. In all cases the civil parishes are the basic units combined to make the areas, except for Bathgate where the two registration districts - Bathgate and Armadale - have been separated. It was felt that this would compensate slightly for the fact that Bathgate, though objectively classified as high shale, really has a very uneven distribution of shale activity and there is none in the Armadale side of the parish.

A1.5.1 Classification 1: Four-way Classification

(i) No Shale Rural (NSR) - Currie, Ratho, Kirkliston ML.

These parishes are primarily agricultural but also border on Edinburgh, and even in the 1920s probably were to a limited degree dormitory areas. There was some shale activity in Kirkliston ML at Ingliston mine, but the mine was very close to the West Lothian boundary and the workers tended to come from Broxburn and Westerton. Very few people lived very close to the mine.

(ii) High Shale (HS) - Uphall, Abercorn, Ecclesmachen, Livingston, West Calder, Mid Calder, Kirkliston WL.

These are the parishes with most shale activity and where the centres of population have all been dominated by the industry both physically and in terms of employment.

(iii) Low Shale (LS) - Linlithgow, Bathgate RD, Kirknewton, Dalmeny.

In each of these there was shale activity in one part of the civil parish, but, either there were other industries (Bathgate - coal, Dalmeny - Naval population and distillery) or a large population not near to or dependent on shale.

(iv) No Shale Industrial (NSI) - Armadale RD, Bo'ness and Carriden, Torphichen, Whitburn.

These civil parishes form a band furthest away from Edinburgh. In all of them coalmining is the major industry, though in Torphichen a large proportion of the population is agricultural. None have any shale activity at all.

A1.5.2 Classification 2: Three-way Classification

This classification arose out of the fact that the mortality analysis of areas classified as above showed little difference between the two shale groups but a substantially lower mortality in the NSR, which was a very small population. This classification aims to link civil parishes together by means of the dominant production in each area.

(i) No Industry - Currie, Ratho, Kirkliston ML, Linlithgow, Torphichen.

Although Linlithgow had some shale activity in the north-east corner, this did not affect the majority of the population. (One woman born in Linlithgow in 1892 had never heard of the shale industry until she went to Broxburn at age 15: Randall, 1990). Torphichen had some coalmining and also contained Westfield paper mill but otherwise was generally rural.

(ii) Shale - Uphall, Abercorn, Ecclesmachen, Livingston, West Calder, Mid Calder, Kirkliston WL, Dalmeny, Kirknewton.

All of these civil parishes had shale activity.

(iii) Coal - Bathgate CP (includes Armadale RD), Bo'ness and Carriden, Whitburn.

These parishes were all dominated by coal production.

Table A1.1 Mine years worked 1911-18; for sources see text.

Civil Parish	mine years	effective oilwork years
Uphall	86	28
West Calder	32	8
Bathgate	32	4
Kirkliston WL*	31	12
Abercorn	23	4
Livingston	17	12
Mid Calder	17	4
Dalmeny	11	8
Linlithgow	10	4
Kirkliston ML*	8	-
Ecclesmachen	8	-
Kirknewton	-	4

* WL: West Lothian
ML: Mid Lothian

Table A1.2 Methods of estimation of annual shale production 1919–62.

1919–1920: The monthly totals were summed.

1921–1927: Totals for January and July were extracted, summed and multiplied by 6 (or less where a full year was not worked).

1928: January total x 12.

1929–1930: Total production April 1929 to March 1930 extracted only – same total production ascribed to each year.

1931–1932: Only total April 1931 to March 1932 available – this total was ascribed to 1931.

1932: Total April–December available – increased pro rata to give total for year.

1933,36,37,40: Totals calculated (Jan + Dec) x 6.

1934,35,38,39,41–62: (Jan + July) x 6 – or where appropriate for number of months worked.

Table A1.3 Oilworks and their civil parishes.

Oilworks	CP of location	Adjacent CPs*
Broxburn	Uphall	-
Roman Camp	Uphall	Mid Calder
Dalmeny	Dalmeny	-
Oakbank	Kirknewton	Mid Calder
Pumpherston	Mid Calder	Uphall
Seafield	Livingston	-
Deans	Bathgate	Livingston
Philpstoun	Abercorn	Linlithgow
Addiewell	West Calder	-
Uphall	Uphall	-
Hopetoun	Kirkliston W. Lothian	Uphall
Westwood	Livingston	West Calder
Niddry Castle	Kirkliston W. Lothian	-

* These are CPs within ¼ mile of the oilworks and with a sizeable population nearby.

Table A1.4 Average annual production (a) and effective throughput (b) in civil parishes (1000 tons). Abbreviated civil parish names; for full names, see Table A2.2.

CP	Uphall		Mid Calder		KLWL		Livingston		West Calder	
	a	b	a	b	a	b	a	b	a	b
year										
1919-20	539	N/A	137	N/A	120	N/A	312	N/A	177	N/A
1921-25	495	617	59	292	131	372	309	334	223	201
1926-30	102	265	-	209	209	385	342	325	214	254
1931-35	119	214	-	134	189	404	390	223	179	272
1936-40	97	275	-	168	210	442	408	164	221	278
1941-45	188	247	-	92	156	546	415	210	299	412
1946-50	194	132	57	62	74	499	322	190	219	378
1951-55	140	105	50	92	51	432	366	236	148	438
1956-60	-	23	25	23	10	289	311	210	78	225
1961-62	-	-	-	-	-	-	139	110	5	110

CP	Abercorn		Bathgate		Ecclesm.		Linlithgow		Dalmeny	
	a	b	a	b	a	b	a	b	a	b
year										
1919-20	576	N/A	363	N/A	84	-	72	N/A	96	N/A
1921-25	551	175	317	168	64	-	66	175	4	130
1926-30	574	166	338	169	92	-	52	166	-	22
1931-35	387	44	90	179	113	-	6	44	-	-
1936-40	317	-	22	164	202	-	-	-	-	-
1941-45	379	-	-	88	151	-	-	-	-	-
1946-50	318	-	-	30	56	-	-	-	-	-
1951-55	366	-	-	-	79	-	-	-	-	-
1956-60	310	-	-	-	36	-	-	-	-	-
1961-62	137	-	-	-	-	-	-	-	-	-

CP	K.Newton		KLML	
	a	b	a	b
year				
1919-20	-	N/A	60	N/A
1921-25	-	77	105	-
1926-30	-	79	15	-
1931-35	-	22	-	-
1936-40	-	-	-	-
1941-45	-	-	-	-
1946-50	-	-	-	-
1951-55	-	-	-	-
1956-60	-	-	-	-
1961-62	-	-	-	-

N/A = not available
 \- = no production

Table A1.5 Classification of civil parishes into shale activity areas: C=current L=lagged 20 years. Abbreviated civil parish names; for full names, see Table A2.2.

(a) Production

	Up		MC		KLWL		Bat		Liv		WC		Ab		Lin		Dal		KLML		Ec		KN	
year	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L
20-30	H		L		H		H		H		H		H		L		L		L		L			
31-40	L				H		L		H		H		H		L						L			
41-50	H	H	L	L	L	H		H	H	H	H	H	H	H		L		L		L	L	L		
51-60	L	L	L		L	H		L	H	H	L	H	H	H		L					L	L		
61-70		H		L		L				H		H		H								L		
71-80		L		L		L				H		H		H								L		

(a) Effective throughput

	Up		MC		KLWL		Bat		Liv		WC		Ab		Lin		Dal		KLML		Ec		KN	
year	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L
20-30	H		H		H		H		H		H		H		H		L						L	
31-40	H		H		H		H		H		H		L		L								L	
41-50	H	H	L	H	H	H	L	H	H	H	H	H		H		H		L						L
51-60	L	H	L	H	H	H		H	H	H	H	H		L		L								L
61-70		H		L		H		L		H		H												
71-80		L		L		H				H		H												

APPENDIX 2

Non-Shale Industrial Activity in the Shale Community Study Area

A2.1 Introduction and Sources of Information

Table A2.1 lists the information sources used to determine the extent of non-shale-related industries in the shale study area. The data available are not of consistently good quality; in few cases is there any quantification of work force size, catchment area or hazards in the industry concerned. Even when these are available they are not systematic over the whole area. The most complete document is the 1958 West Lothian Planning Survey (e) which contains detailed tables of the place of residence (in WL) of all shale workers and coalminers as well as statistics on numbers employed in each shale and coal related place of work. It is however limited to West Lothian and there is no comparable document for the Mid Lothian shale areas of West Calder, Mid Calder and Kirknewton.

Another source of information on West Lothian (d) provides details of industries (it was prepared as a document to persuade industrialists to invest in West Lothian and start up new industries there and thus spends many pages extolling WL's virtues), incidental data on unemployment and a detailed description of the water source in most villages as well as the chemical analysis of the water. The Ordnance Survey maps (a, b and Table A2.1A) are a reliable source as to the location of an industry, but although the 1922 edition is relatively specific as to the sort of mine, works, quarry or factory the 1954 edition is far less detailed.

A2.2 Description of Non-Shale Industry by Civil Parish

In Table A2.2 the available data are presented for each civil parish in turn, with an indication of the source of the information. All mention of shale mines, oilworks and directly shale dependent industries (refineries, candle-houses etc.) have been omitted in order to provide a clearer picture of the alternatives. Also omitted is all mention of agriculture and forestry both of which occur in most of the civil parishes, farming to a considerable extent. For each civil parish the 'shale activity' classification is given (used for the analysis of the extracted death data and discussed in Appendix 1).

A2.3 The Possibilities of Non-shale Industrial Hazards

2.3.1 Civil Parishes classified as 'No Industry' (Appendix 1)

Three of the civil parishes classified as being 'no industry' (Currie, Ratho and Kirkliston ML) had little industry except paper mills which are still operating. In Linlithgow, there are no heavy industries and no coalmining, although the area is not devoid of industrial activity. By 1958 the burgh was considered as 'an attractive residential area for persons employed in the Grangemouth Oil and Petro-chemical industries, and the population increase rate will reflect the expansion of private residential development in the royal burgh'. It was said of the District Council area (= CP) that 'the decline in population will continue in this predominantly rural area despite the expected increase in development in the County town'. In 1957, 32 coalminers and 43 shale workers lived in Linlithgow burgh, plus another 75 shale workers in the District of County, out of a total population of about 7600.

Torphichen CP was dominated by the Westfield paper mill which was working through from 1914 until at least 1964. Blackridge, a village in the westernmost corner was a coalmining village. Most of the deaths in this village in the registers 1911–31 were to coalminers, their wives or children. In 1957, of an estimated total population of 2100 in Blackridge, 391 were coalminers. The total population of the CP in 1961 was only 3054, indicating that despite its rural appearance it was heavily dependent on coal.

A2.3.2 Civil Parishes classified as 'Shale' (Appendix 1)

In many of these civil parishes there were little or no industrial risks from factors other than shale. Abercorn, Dalmeny and Ecclesmachen had no other industrial risks while the Winchburgh brickworks in Kirkliston was dependent on the shale industry. Until 1958 there was very little non shale related activity in Uphall apart from the sulphuric acid works, which was said by some old people to have given off choking fumes. This works was however part of the oilworks and involved in the ammonium sulphate by-product. Industrial activity in Mid Calder included some limestone mines but these had more or less ceased production by the study period. The Camilty gunpowder factory in the same civil parish only employed 20 people and was in such an isolated area that it can have had no effect on the population.

However, two of the civil parishes classified as 'Shale' (Livingston and West Calder) straddled the coal and shale bands. Although the majority of Livingston is shale, in the western corner was Riddockhill colliery which was working by 1914 and continued until 1968. In 1959 this colliery employed 652 men of whom 477 were from W. Lothian, 39 from M. Lothian and 136 from Lanarkshire. At that date, Blackburn, a village in Livingston parish had 716 men employed in coalmining out of an estimated population of 3500. Forty-four men were employed in the shale industry. Today, Blackburn people consider themselves part of a coalmining community. Of the other villages the employment in 1957 was as follows:

	pop.	coal	shale
Blackburn	3500	716	44
Seafield	1200	27	167
Livingston Station	1500	0	184
Livingston Village	165	6	0

This was towards the end of the shale industry, and for much of the previous period, shale employment in Livingston will have been much higher.

In West Calder collieries such as Loganlea and Woodmuir were working in 1914 right through to 1959 and 1963 respectively. Baads mine was owned by Scottish Oils to provide coal for the oilworks. The village of Briech was a coalmining village whereas Addiewell and West Calder were dominated, though not exclusively, by shale. In this area people did leave the shale to go to coal because the coal was quite near. 'Anyway I was 34 years ... with the Scottish Oils in the shale mines ... and I left there and I went to the coal, as a deputy and I worked the coal for 16 year ... at Greenrigg, the other side of Polkemmet.' (West Calder man interviewed Jan 1985.) This interchange between shale and coal had gone on in earlier years of shale depression. 'When I came back from the army (1918/9) I'd no job ... and this chap and me went up to the Shotts. Well, we got a job up there. We'd ha' taken any job. It was at a pit I got this job – we were surface men.' (Addiewell man interviewed Dec 1985.)

A2.3.3 Civil Parishes classified as 'Coal' (Appendix 1)

These three parishes (Bathgate, Bo'ness & Carriden and Whitburn) were all dominated by the coal industry. Although Bathgate definitely does have some shale activity the extent of its coalmining and heavy industries heavily outweighs that of shale, particularly when the distribution of population is taken into account. In 1914 there were five working collieries and two were still working into the 1970s. A steel works, spade and shovel works and the chemical works (originally part of the shale industry) may all have had an effect on the population (see Lloyd below). After the war Bathgate continued to be an industrial centre but after mining the main employer was the condenser factory. The BMC plant, started in 1961 coincided with the demise of the shale industry and it seems that many shale workers from all over West Lothian went to work there. In 1957, 814 Bathgate men worked in coal mines and 23 in shale.

The main problem with using these parishes as a comparison area is that their environmental and occupational risks may be greater than those of shale and are quite likely to be similar (Lloyd *et al*, 1978, 1979, 1984, 1985; Seaton 1985) for respiratory disease and lung cancer.

A2.4 The General Industrial Situation in Mid and West Lothian - 1911-64

A2.4.1 1911-62

The principal industrial feature of West Lothian and the shale areas of Mid Lothian was the amount of extractive industry going on. Apart from shale and coal, there are numerous quarries, limestone mines, sand pits and fire clay mines. Some of these coexist in the same areas, others, like coal and shale are in bands across the counties. All apart from coal and fire clay have diminished in importance throughout the twentieth century. Coalmining too has contracted rapidly since the 1940s; the closure of Kinneil colliery in 1984 and Polkemmet in 1986 signal the end of coalmining in the area. Non shale related heavy industry is concentrated in and around the traditional coalmining areas of Armadale and Bathgate where there have been iron and steel foundries dating from before the first world war. However, the evidence indicates that few of the shale workers pushed out of their own industry were re-employed in coal and the other heavier industries. The 1935 document, written in order to attract new industries to the area states, as an attraction, that there are large numbers of unemployed workers in Philpstoun and Kingscavil (both ex-shale areas). In Linlithgow there were 'about 800 skilled, semi-skilled and ordinary workers available for new industries' and Queensferry had 'an ample source of unskilled labour'. All this indicates that shale workers had not yet been absorbed into other local industries. The approximate wage for unskilled labour in 1935 was £2 per week, rather less than an employed shale miner was getting: about £3 per week (Randall, 1990); and 'holidays with pay are not customary for manual workers'. Thus, as early as 1935 the shale industry had contracted sufficiently for the West Lothian Council to be trying to attract new industry. The county handbooks for 1958 and 1964 continue in this tradition.

The effects of these attempts to attract industry can be seen from Table A2.2 showing industry by civil parish. At Bathgate the post war condenser factory, BMC plant, and at Broxburn the United thread mill and the Golden Wonder Crisp factory have all been attracted in. Few of these new industries are likely to have had a major impact on health and mortality of the surrounding communities: they were mainly light industries and less polluting than the processes which they replaced. In terms of health of the community, the high levels of unemployment in areas which failed to attract new industry, and also those areas where subsequent closure of factories has led to an increase in the jobless (Bathgate) may have a more important effect on mortality then any environmental conditions (Moser *et al*, 1984). Many of the new industries employed more women than men, and male unemployment has been high in the area since the shale industry started to collapse.

The iron and steel foundries at Bathgate and Armadale are an exception to this pattern of light industry. Both were established before the first world war and both are in the non shale comparison group. Thus it is important to know about the possible environmental and other hazards there. O.L. LLoyd and others have done detailed studies of the areas surrounding the Armadale foundry and less detailed work around Bathgate (Lloyd *et al*, 1978, 1979, 1984, 1985). Lloyd's work has involved taking samples for pollution around the foundries and then careful mapping of the most polluted areas after which mortality was investigated. The studies show raised levels of mortality from lung cancer in the areas closest to the foundries and downwind. They also show that during the 1960s Armadale had the highest SMRs of all-cause mortality of all the small burghs in Scotland. (This is not the first time that Armadale has been picked out amongst burghs in Scotland: in the 1911 census it had the highest proportion of its population living in one-roomed houses (27%) and the lowest proportion living in houses of more than two rooms (17.2%). It had the highest percentages of people living more than two to a room, three to a room and four to a room.) Lloyd's work is important for the shale community study not only because it documents and measures an effect on mortality of industrial pollution, but also because Armadale and Bathgate are two of the comparison areas for the shale areas. If they have high mortality this may mask any excess mortality in the shale areas.

A2.4.2 Changes after 1962

Since 1962 and the closure of the shale industry along with the contraction of the coal industry, documenting other industrial risks in the area has become more complex because of increasing diversity. The creation of industrial sites has led to a mushrooming of small manufacturing industries with small work forces and the creation of Livingston New Town has also complicated things. Grangemouth Refinery too is of increasing importance even though it is outside the study area. Many of the shale workers were offered jobs at Grangemouth and commuted to work. Even now, Linlithgow and Bo'ness are Grangemouth dormitory towns. The expansion of the refinery has brought it closer to Bo'ness and with the prevailing Westerly winds there is no doubt that the atmospheric pollution must, at times be considerable. This may be important if Lloyd's work in Armadale can be extended to other areas and other industries.

Table A2.1 Sources of information of industrial activity.

(a) 6" ordnance survey maps revised around 1914. (See Table A2.1A)

(b) 6" ordnance survey maps revised around 1954. (See Table A2.1A)

(c) 1927 Report on the labour position in the Scottish shale oil industry. (BP Grangemouth Archives AR1052)

(d) 1935 County of West Lothian: statement of facilities and advantages as an industrial centre. (Scottish National Library)

(e) 1958 West Lothian County Planning Survey. (Bathgate Library HQ)

(f) 1958 West Lothian Official Industrial Handbook. (Scottish National Library)

(g) 1964 West Lothian: The Official Industrial Handbook. (Scottish National Library)

(h) 1964 Mid Lothian: The Official Handbook of the County. (Scottish National Library)

(i) 1947+ List of collieries near oil shale area with closing date. These were collieries taken over by the National Coal Board. List prepared by R Annis and W Lawrence of the IOM.

(j) Undated (c. 1983): Bathgate on the Edge. pub. SEAD, 29 Nicholson Square, Edinburgh.

(k) Lloyd OL, Barclay R. (1979) A short latent period for respiratory cancer in a susceptible population. Community Medicine; 1: 210-20.

(l) Interviews with old people in Mid and West Lothian (Randall, 1990).

Table A2.1A List of maps used.

Source: Six inch to the mile Ordnance Survey maps.
Edition: Around 1922 and around 1954.
Location: National Map Library of Scotland.

(i) 1922 Edition - maps used

		Number	Edition	Revised
Linlithgowshire	New Series	NI/II	1922	1910
"	" "	NIII	1922	1913/14
"	" "	NIV	1922	1913/14
"	" "	NV	1922	1914
"	" "	NVI	1922	1910
"	" "	NVII	1922	1913
"	" "	NVIII	1922	1913/14
"	" "	NIX	1923	1914
"	" "	NX	1922	1913/14
"	" "	NXI	1922	1913/14
"	" "	NXII	1922	1913
"	" "	NXIV	1922	1914
Edinburgh		VI-NW	1908	1905
"		VI-SE	1915	1912
"		VI-SW	1908	1905
"		XI-SE/SW/NE	1908	1905
"		XII-SW/NW	1908	1905
"		parts of X,XI,XVI,XVII	1922	1905

(ii) Provisional Edition - around 1954: revised before 1930 but with major changes added in 1954.

NT 05 NW/SW	NS 86 NE
NT 06 SE/SW/NE/NW	NS 95 NE/NW
NT 17 SE/SW/NW	NS 96 SE/SW/NE
NT 16 SE/SW/NW	NS 97 SE/SW/NE
NT 08 SW	
NT 07 NW/SW/SE	

Note: This provisional series is far less specific than the earlier (1922) edition. Type of works, mine or mill and name was specified in the 1922 edition, but only referred to as 'mill' or 'works' or 'mine' in the later edition.

Table A2.2 Summary notes describing non-shale industry by civil parish.

Abercorn (high shale/shale)

1914:	(a)	Quarries: Craigton, several old quarries.
1954:	(b)	Quarries: Craigton.

Armadale (no shale industrial/coal)

1914:	(a)	Collieries – Armadale, South Broadrigg, Bathville. Coalmine – one in burgh. Brickworks – South Broadrigg, Etna, Atlas + 1 Bathville. Brick and fireclay works – Barbauchlaw + 1 very big. Steel works – Atlas (started 1913). Quarries – 1 in burgh, several old quarries.
1935:	(d)	Brickworks – 'several well-appointed brickworks' capacity 100,000 bricks/day, Atlas (firebricks), Bathville (sanitary pipes, chimney pots, all kinds of fireclay goods. Steel foundry. Hosiery factory.
1947:	(i)	Colliery – Barbauchlaw (closed 1952).
1958:	(e,f)	Fireclay works. Two large steel foundries. Factory – colliery equipment. Two small hosiery factories. Brickworks – National Coal Board. Coal briquette factory. Sand pit.
1964:	(g)	New firebrick plant. Steel foundries – Atlas, West Lothian. United fireclay. Mayfield hosiery (started 1938). Dickson & Mann (started 1961) – makes and installs conveying equipment. Large sand pit.

Bathgate (low shale/coal)

1914:	(a)	Collieries – Northrigg, Mosside, Boghead, Hopetoun, Balbardie + 2 disused. Fireclay – Drum Fireclay pits, Tileworks and claypit. Chemical works – Durhamtown. Brickworks – Asbestic sand. Sandpit – Balbardie + others + others (disused). Quarries – several + several (disused). Steel works – Balbardie. Iron foundry (1907). Spade and shovel works (1877). Hosiery factory. Gas works. Sawmill.

Distillery - Glenmains.
Old gravel pits, limeworks (disused), South mine limeworks and lime kilns (disused).

1935: (d) Steel rolling mills (1896) - 40-50 tons shovel plates, 200 tons steel sheets per week.
Spade and shovel works - 25-30,000 household shovels, 7-8000 large shovels per week + spades of all descriptions.
Hosiery factory - 'good type of female employee'.

1947: (i) Collieries - Bridgend (closed 1964), Easton (closed 1973), Hopetoun (closed 1973).

1954: (b) Seven coal mines.
Four works.
One mill.
Nethermains works.

1958: (e,f) Collieries.
Two fireclay mines.
One sand/gravel pit.
Bathgate sulphuric acid works - dismantled 1957/8, 11 employees.
Large modern steel foundries.
Brass foundry.
Steel spade and shovel factory.
Several hosiery factoriess - employed many female workers.
Condenser factory - opened 1947, largest single employer excl. mining, largest female employer (closed 1982/3).

1964: (g) Collieries.
BMC truck plant (1961) - will employ 5600.
Spade and shovel factory.
N. British steel foundry.
W. Lothian knitwear.
Condenser factory.
Grieg Bros - large electrical business.

Bo'ness and Carriden (no shale industrial/coal)

1914: (a) Collieries - Kinneil, Bridgeness, Grange, Westernfield.
Sawmills - 4.
Kinneil mills.
Timber - basin, 4 yards.
Distillery.
Docks.
Pottery - Bridgeness.
Quarries - Maiden Park + several old.

1935: (d) Coalmines.
Pottery.
Hosiery factories.
Ship breaking yard.
Numerous pitwood yards.
Chemical manure works.
Iron foundries.
Sleeper yard.
Bonded stores.
Port and harbour.
Distillery and pottery - no longer operating.
Hosiery factory with dye works - adapted for dying 'the latest fancy shades'.

1947:	(i)	Kinneil colliery (closed 1984).
1954:	(b)	Nine mills.
		Five works.
		Three coalmines.
		Dock.
		Maltings.
		Two factories.
1958:	(e,f)	Colliery - Kinneil.
		Number of timber yards and joinery.
		Two old established iron foundries.
		Pottery (closed 1958).
		Two small hosiery firms.
		Wool yarn factory.
		Chemical fertiliser works.
		Distillery.
		Ship breaking yard.
1964:	(g)	Colliery - Kinneil.
		Timber - new joinery factory being built, 100 workers, joinery Carriden.
		Iron works - A Ballantine and sons (1864).
		Hosiery.
		Distillery.
		Wool yarn spinning.
		Ship breaking.
		Docks closed.

Currie (no shale rural/rural)

1914:	(a)	Paper mills - Kinleith, Balerno.
		Saw mill.
		Baberton quarry (disused).
1954:	(b)	Paper mills - Kinleith, Balerno.
1964:	(h)	Paper mills - Kinleith, Balerno (both still working 1985).
		Two other manufacturing and metal industry.

Dalmeny and Queensferry (low shale/shale)

1914:	(a,l)	Whisky blending and bottling.
		North British creosote works.
		Saw mill.
		Craigie quarry.
1935:	(d)	'The only industry (in Queensferry) is whisky blending and bottling'.
1958:	(b,e)	Depot - Queen Elizabeth yard.
		One sand/gravel pit.
		Blending, bottling - destroyed by fire 1949, rebuilt mid 50's.
1964:		Distillery.

Ecclesmachen (high shale/shale)

1914:		Old quarries.

Kirkliston Mid Lothian (no shale rural/rural)

1914: Nothing.
1954: Poultry farm.

Kirkliston West Lothian (high shale/shale)

1914: (a) Distillery - Kirkliston.
Clay pit.
Humbie quarry (disused).
Brickworks - Winchburgh.
1927: (c) and 1935: (d) Distillery.
Brickworks - building bricks, agric. drain tubes.

Kirknewton (low shale/shale)

1914: (a) Quarries - Camps, several disused.
Brickworks - Camps.
1954: (b) Quarries - Little Vantage, Camps.
Camps works.
1964: (h) One other extractive industry.
One other manufacturing and metal work.

Mid Calder (high shale/shale)

1914: (a) Limestone mines - Westfield + 2 disused.
Gunpowder factory - Camilty.
Quarries - 2 disused.
1927: (c,l) Camilty gunpowder factory - employed 20 people.
1954: (b) Brick kiln and brickworks - Pumpherston.
1964: (h) Pumpherston refinery - continues to process crude oil, paraffin wax, detergents and SOL building bricks.
Two food manufacturing factories.

Linlithgow (low shale/rural)

1914: (a) Quarries - Hillhouse, Mary Dickie's + many disused.
Sawmill.
Gravel pit.
Paper mills - Loch mill, Avon.
Rivald's Green tan works.
Gowan Stank glue works.
Distillery.
St Magdalen's engineering works.
Baron's Hill factory.
Regent factory - explosives.
1935: (d) Paper mills - Loch mill, Avon.
Boot manufacturing, tanning and curing leather.
Norbel's explosives company - safety fuses.
1954: (b) Fireclay.
Sandpit.
Mains maltings.
Distillery.
Four works - 1 pharmaceutical processing and packing.

		Blowshennie whinstone quarry.
		Paper mills - Loch mill, Avon.
1958:	(e,f)	Pharmaceutical chemical factory.
		Brewery.
		Distillery.
		Agric-engineering works.
		Two well established paper mills.
1964:	(h)	Paper mill - Loch mill.
		ICI Regent works (pharmaceuticals) - employs 400-500.

Livingston (high shale/shale)

1914:	(a)	Riddockhill colliery.
		Old quarries.
1947:	(i)	Riddockhill colliery - closed 1968.

Ratho (no shale rural/rural)

1914:	(a)	Quarries - Ravelrig, Norton, Craigpark, Ratho, Hillwood + 1 + several old quarries.
1954:	(b)	Quarries - Norton, Hillwood, Goldenacre, Ratho, Craigpark.
1964:	(h)	Three other extractive industries.
		Three food processing industries.
		One other manufacturing and metal.

Torphichen (no shale industrial/coal)

1914:	(a)	Collieries - Woodend, Blackrigg.
		Westfield paper mill (big).
		Quarry - Blackridge + many old quarries.
1935:	(d)	Paper mill - largest in West Lothian.
1947:	(i)	Collieries - Woodend (closed 1965), Blackridge (closed 1955).
1954:	(b)	Paper mill.
		Sand pit.
		Coalmine.
1958:	(e,f)	Large paper mill.
		Sand pit.
		Roadstones materials.
		Fireclay mine.
		Craigrigg - small private brickworks.
1964:	(g)	Westfield paper mill.
		John Stein fireclay mine - super duty fireclay bricks, 3 manufacturing plants, employs 1700.

Uphall (high shale/shale)

1914:	(a)	Electrical power station.
		Gas works.
		Old quarries.
		Old clay pits.
1927:	(c)	Broxburn sulphuric acid works - 36 employees.
1958:	(e,f)	Broxburn sulphuric acid works - 52 employees.

		United thread mills - 100 females.
		Steel castings foundry - 35 employed expanding to 200.
		Bookbinding firm.
		Electrical domestic appliance factory - 160 employed.
		Chemical fertiliser works.
1964:	(g)	£1m development of Golden Wonder crisp factory.
		Light transformer factory - will employ 400.
		United thread mills - synthetic fibres.
		Motherwell thermal - manuf. condensers, air cooled heat exchangers, etc.
		Broxburn - shotblasting to remove sand and scale from steel castings.

West Calder (high shale/shale)

1914:	(a)	Collieries - Woodmuir, Loganlea.
		Quarries - Rusha, Torphin.
		Lime works - N. Cobbinshaw, Harburn, Kilnburn.
		Brickworks - Hermand.
		Iron mines apparently disused.
		Many old coal shafts and disused quarries.
1947:	(i)	Collieries - Baads (closed 1962), Harwood (closed 1959), Loganlea (closed 1959), Woodmuir (closed 1963).
1954:	(a)	Collieries -Baads, Loganlea, Woodmuir.
		Quarries - Rusha.
		Levenseat quarry works.
		Works (in middle of nowhere).

Whitburn (no shale industrial/coal)

1914:	(a)	Collieries - Whitrigg, Foulshiels, Crofthead, Fauldhouse, Braehead, Cultrig, Greenrigg, Southrigg.
		Coalmines - Burnbrae.
		Quarries - Fallahill.
		Disused brickworks, quarry and colliery.
1947:	(i)	Collieries - Benhar (1962), Blairmuckhill (1959), Cuthill, Stoneyburn (1960), East Benhar (1957), Foulshiels (1957), Greenrigg (1960), Knowetop (1966), Polkemmet, Whitrigg (1972).
1958:	(e,f)	Fallahill quarry.
		Fireclay mine.
		Polkemmet colliery - 1450 men.

APPENDIX 3

Checking Population at Risk Estimates using Linear Interpolation

A3.1 Method of Interpolation

For estimating annual populations from the decennial censuses linear interpolation was used. This was done in preference to the more complicated, and potentially more accurate, component interpolation and projection primarily because of lack of data. No birth data are available at civil parish level, neither are all deaths before 1963. Migration was a dominant feature of these populations in 1911–31 and the pattern has not changed: Edinburgh has expanded into some parishes, much new housing has been built, many heavy industries have disappeared, and Livingston New Town was built in the study area. Although the importance of migration undermines the validity of linear interpolation as a model for population change, without more data any model would be inaccurate. Linear interpolation is the simplest to apply and, as observed below, in the year when we can check its validity, it is surprisingly accurate in estimating total population with no systematic bias by age.

A3.2 The 1966 Sample Census

All the data outlined above were for the main census years. Fortuitously the 1966 sample census occurred at the time when there was greatest population change in the study area, and also provided 100% coverage of much of the study population (1966 sample census; report on the special study areas).

1966 data are not available for civil parishes but are published for Districts of County. To check our interpolations the CPs constituting the Districts of County were added together for 1961 and 1971 and interpolated through. The estimated mid year population for 1966 was then compared with the actual populations reported in the census (Table A3.1).

Each of these Districts of County is constituted by one to three civil parishes which themselves have very different patterns of growth over time (Table A3.2). Bearing this in mind the correspondences between the published and interpolated figures are very good. The exceptions are shown below.

A3.2.1 West Calder

The population in 1966 is lower than in either 1961 (6873) or 1971 (6926). No form of interpolation would have been able to predict this. As this is the one case where the CP is a District of County the interpolations have been split and done for 1961–66 and 1966–71.

A3.2.2 Whitburn and Livingston

The explanation of the differences here must be differential house building programmes throughout this decade. Little can be done to control for this. The discrepancy is not very high, and interestingly is of a similar magnitude to that of West Calder.

A3.2.3 East Calder and Kirknewton

Here the discrepancy is very large because Livingston New Town, the major part of which is in Mid Calder parish, was begun after 1966. There was extremely rapid house building and families were attracted in from a very wide catchment area. Over the whole decade Mid Calder civil parish grew by 405.8%.

In this last case some preliminary work was necessary in order to decide how best to deal with the problem. This referred to the 1961 and 1971 Index of place names (produced in conjunction with the census and giving the population for each place), a street map of Livingston New Town and the census civil parish populations.

Between 1961 and 1971 the population of Livingston CP increased from 7404 to 11691 (an increase of 4287). Three thousand four hundred and sixty-nine individuals of this increase were in Blackburn village completely independent of Livingston New Town. Thus throughout the decade there was little development of the New Town in Livingston Civil Parish and most of the New Town growth was in Mid Calder CP. The estimated population in the LNT boundary of 1961 was 1795 (an underestimation from the Index of place names) and the LNT population (published) in 1966 was only 2415. This confirms that most growth was after the sample census.

In order to interpolate Mid Calder CP from 1961–66 and 1966–71 the 1966 District of County had to be split into its component civil parishes. This was done by treating both sexes separately and splitting each age group in the 1966 D of C according to the ratio of Kirknewton:Mid Calder in that age group in 1961. Thus two civil parish populations were obtained for 1966. The total population for the District of County hardly changed from 1961 to 1966 (males decreased from 3200 to 3192 and females increased from 3198 to 3200).

Another method of estimating Mid Calder CP population in 1966 was tried, but failed. This assumed that Kirknewton had linear growth throughout the decade. Kirknewton was interpolated from 1961 to 1971. The estimated 1966 population was subtracted from the 1966 D of C population with the remainder assumed to estimate Mid Calder. This worked well for most age groups but caused a curious age distribution of young women with 104 15–19 year olds and only 34 aged 20–24. The first method produced a much more regular distribution.

A3.3 Accuracy of Interpolation by Age Group

Table A3.3 gives the published and interpolated populations for Torphichen and Bathgate by age group. It shows that for the interpolated populations there are no systematic biases by age although some age groups differ by as much as 10%. This can be considered a consequence of random fluctuations.

A3.4 Effect of Errors in Risk Groups on Death Rates

Although we were able to correct for distortion in Mid Calder, at other times, as in Whitburn and Livingston, no correction can be made, and usually we will be unaware of the discrepancy. From the 1966 checks above, the errors seem to be either negligible or in the realms of 7% error in either direction.

To examine the effect that an error of this magnitude might have on death rates two tests were made using all of Scotland data for 1966. The Scottish CDR and crude male lung cancer death rates were applied to the West Calder and Whitburn & Livingston 'true'

1966 populations to get expected deaths. These were then divided by the interpolated 1966 populations to get 'apparent' death rates where the true death rate would be equal to that of Scotland.

	CDR o/oo	male lung cancer DR o/o,oooo
Scotland (true rate)	12.27	10.51
West Calder (apparent rate)	11.47	9.82
Whitburn & Livingston (apparent rate)	13.23	11.32

Table A3.1 Comparison of interpolated and reported populations 1966.

District of County		Reported pop.	Interpolated pop.	% difference
Currie	M	5999	6054	+0.9
	F	6337	6324	-0.2
Uphall	M	6393	6344	-0.8
	F	6960	6920	-0.6
Whitburn & Livingston	M	15180	14095	-7.1
	F	15092	13975	-7.4
Kirknewton & E.Calder	M	3192	6328	+98.2
	F	3200	6260	+95.6
West Calder	M	3225	3446	+6.9
	F	3247	3453	+6.3
Torphichen & Bathgate	M	13399	13329	-0.5
	F	13770	13771	0.0

Source: 1966 sample census: report on the special study areas.

Table A3.2 Civil Parish population change 1911-31, 1951-81 counts and inter-censal increase.

Parish	1911	1921	1931	1951	1961	1971	1981
Abercorn	933	1000	775	806	612	523	543
		7.2	-22.5		-24.1	-14.5	3.8
Bathgate	17659	18862	18064	19755	22506	25505	24427
		6.8	-4.2		13.9	13.3	-4.2
Bo'ness	14034	13394	14098	14136	14207	13383	15247
		-4.6	5.3		0.5	-5.8	13.9
Dalmeny (1)	3629	3995	3231	3580	4141	6534	9705
		10.1	-19.1		15.7	57.8	48.5
Ecclesmachen (2)	741	705	745	663	742	1281	977
		-4.9	5.7		11.9	N/A	N/A
Kirkliston WL (3)	4467	4579	3975	4058	4238	4941	5644
		2.5	-13.2		4.4	16.6	14.2
Linlithgow	7567	7631	7157	6811	7277	8522	11297
		0.8	-6.2		6.8	17.1	32.6
Livingston	3714	4745	4415	6473	7404	11691	18352
		27.8	-7.0		14.4	57.9	57.0
Torphichen	4048	4486	4175	3587	3054	3139	2993
		10.8	-6.9		-14.9	2.7	-4.7
Uphall	12766	12497	11119	11114	10719	12417	15061
		-2.1	-11.0		-3.6	15.8	21.3
Whitburn	8379	11506	12629	16099	16203	20842	21542
		37.3	9.8		0.6	28.6	3.4
Currie	2519	2660	3261	3235	6359	11165	13475
		5.6	22.6		96.6	75.6	20.7
Kirkliston ML (3)	831	835	810	964	1004	1060	943
		0.5	-3.0		4.1	5.6	-11.0
Kirknewton (4)	2873	3000	2910	3314	3639	4819	5634
		4.4	-3.0		9.8	32.4	16.9
Mid Calder	3249	3207	2793	2591	2760	13959	26754
		-1.3	-12.9		6.5	405.8	91.7
Ratho	1883	1751	1672	1590	2176	2977	3476
		-7.0	-4.5		36.9	36.8	16.8
West Calder	7716	7874	6817	7658	6873	6926	7063
		2.0	-13.4		-10.2	0.8	2.0

(1) = excluding naval and shipping populations.
(2) = excluding Bangour hospitals 1911-61; 1971-81 de jure populations.
(3) = boundaries throughout as before reorganisation in 1974.

Table A3.3 Torphichen and Bathgate: comparing age distribution of published and interpolated populations 1966.

	Males			Females		
Age	pub. pop.	interp.	%diff	pub.pop.	interp.	%diff
0-4	1367	1341	-1.9	1233	1214	-1.5
5-9	1293	1291	-0.2	1206	1191	-1.2
10-14	1169	1221	4.4	1085	1194	10.0
15-19	1127	1014	-10.0	1100	1010	-8.2
20-24	881	918	4.2	916	981	7.1
25-29	903	893	-1.1	911	899	-1.3
30-34	889	879	-1.1	927	906	-2.3
35-39	844	885	4.9	867	928	7.0
40-44	866	832	-3.9	910	856	-5.9
45-49	865	839	-3.0	868	851	-2.0
50-54	809	811	0.2	829	826	-0.4
55-59	745	749	0.5	757	769	1.6
60-64	633	593	-6.3	726	671	-7.6
65-69	419	460	9.8	563	554	-1.6
70-74	289	280	-3.1	396	438	10.6
75+	300	320	6.7	476	479	0.6
	13399	13329		13770	13771	

APPENDIX 4

1911–31 Deaths traced in Shale Study Area and Percent missing by Year and Sex

	Males			Females		
Year	traced	publ.	% missing	traced	publ.	% missing
1911	692	722	4	685	691	1
1912	675	707	5	659	663	1
1913	630	666	5	618	631	2
1914	662	677	2	606	633	4
1915	746	780	4	605	640	5
1916	612	647	6	524	554	5
1917	637	676	6	594	626	5
1918	774	812	5	711	734	3
1919	648	682	5	572	601	5
1920	580	622	7	526	553	5
1921	604	643	6	560	578	3
1922	664	703	6	542	576	6
1923	603	626	4	507	537	6
1924	565	608	7	540	563	4
1925	563	600	6	534	566	6
1926	560	605	7	493	520	5
1927	613	636	4	485	504	4
1928	565	616	8	477	506	6
1929	583	622	6	541	583	7
1930	595	627	5	523	544	4
1931	541	N/A		488	N/A	

APPENDIX 5

Definition of Causes of Death

Abbreviated Name	9th revision	8th revision	6/7th revision
1. MN–Mouth	140-149	140-149	140-149
2. MN–Stomach	151	151	151
3. MN–LgInt	153	153	153
4. MN–Rectum	154	154	154
5. MN–Liver	155.0	155.0	155.0,155.1
6. MN–OthDig	rem(150-159)	rem(150-159)	rem(150-159)
7. MN–Respty	160-165	160-163	160-165
8. MN–Skin	173	173	191,179.1
9. MN–Breast	174,175	174	170
10. MN–BoCon	170-172	170-172	190,196,197
11. MN–Cervix	180	180	171
12. MN–Bladder	188	188	181
13. MN–Kidney	189.0,189.1	189.0,189.1	180
14. MN–OthGenUn	rem(179-189)	rem(180-189)	rem(171-181)
15. MN–Lymph	200-209	200-209	200-205
16. MN–OthUnk	190-199	190-199	190-199
17. Neounk + Ben	210-239	210-239	210-239
18. TB	010-018	010-019	001-019
19. EndAlMet	240-279	240-279	250-289
20. Blood	280-289	280-289	290-299
21. Psychos	290-299	290-299	300-309
22. NeurSens	320-389	320-389	335-398
23. IschmHt	410-414	410-414	420,422.1
24. Cerebvasc	430-438	430-438	330-334
25. OthCirc	rem(390-459)	rem(390-458)	rem(400-468)
26. BronchEmp	490-493	490-493	500-502,241
27. IndustDis	500-508	515-516	523-524
28. OthRespy	rem(460-519)	rem(460-519)	rem(470-527)
29. Digestive	520-579	520-577	530-587
30. GenUny	580-629	580-629	590-637
31. Muskel	710-739	710-738	720-749
32. IllDefnd	780-799	780-796	780-795
33. OthInt	rem(001-799)	rem(001-799)	rem(001-799)
34. External	E800-E999	E800-E999	E800-E999

APPENDIX 6

Details of Cohort Analysis

A6.1 Illustrative Example of Calculation of Cohort

For the 1953–81 data analysis could be done for five pivotal years – 1957 (covering 1953–61), 1962 (1958–66), 1967 (1963–71), 1972 (1968–76) and 1977 (1973–1981).

For the 1935 cohort (born 1933-37) in the age group 20-24:

1953	those	aged	20	are members	of	the	cohort
1954	"	"	20,21	"	"	"	"
1955	"	"	20,21,22	"	"	"	"
1956	"	"	20,21,22,23	"	"	"	"
1957	"	"	20,21,22,23,24	"	"	"	"
1958	"	"	21,22,23,24	"	"	"	"
1959	"	"	22,23,24	"	"	"	"
1960	"	"	23,24	"	"	"	"
1961	"	"	24	"	"	"	"

giving 25 years of total experience

A6.2 Statistical Analysis of Cohort Data

As noted in section 2.6.3, log–linear regression models for the analysis of rates can be extended in a straightforward manner to allow investigation of cohort effects along with effects attributed to age and period of death as well as other factors such as region. A detailed and useful exposition is given by Osmond and Gardner (1982), and the notational conventions in this section are based on theirs.

A rectangular table of rates for I age groups observed over J time periods contains contributions from K=I+J–1 birth cohorts (where the age–groups and time periods for both births and deaths are all of the same length). If we subscript the rates with the corresponding lower–case letters, and introduce a further dimension subscripted by l to allow for, say, variation between regions, we can set up a simple model such as

$$\log(r_{ijl}) = a_i + b_j + c_k + p_l$$

This is a particular example of the regression–type model exhibited in 2.7.3 of the main report, and the remarks made there apply in this case. It is required to estimate, and to assess the statistical significance of, the age effects a, the period effects b, the cohort effects c, and the regional differences p.

It is clear that cohort effects cannot be totally independent of age and period effects; indeed, if the logarithms of the rates change linearly (or not at all) over the periods, then it is not possible to distinguish between age+period, age+cohort or age+period+cohort models. If the pattern of change is more complex than a straight line, however, then it is possible, using the usual maximum likelihood tests, to assess which of these combinations best fits the data. (The test criteria given by equation (2) of Osmond and Gardner (1982) are similar but not identical to those derived by maximising the likelihood. We have used the latter throughout.)

Finally, it should be noted that the model equation above is intended as a particular example, but it is not the only possible such model; the same methodology allows the introduction of further differential factors such as sex, and the creation of terms to represent interactions between the factors of the model.

A6.3 Cause–specific Cohort Death Rates

Tables A6.1–A6.7 give the calculated cohort deaths rates for the causes of interests listed in section 3.7. Details of the tables are also given in this section of the main report. A schematic diagram of the relationship of the individual cohorts to age group and pivotal year of death is given in Table A6.8

Table A6.1 Cohort death rates for all cause mortality.

Area	Pivotal Year	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
Males										
Shale	67	3.42	5.92	10.89	21.26	30.16	56.91	70.85	125.51	136.62
	72	3.36	6.30	11.51	15.62	32.67	49.52	71.90	110.38	161.85
	77	2.52	6.75	12.02	17.46	29.04	46.04	69.29	113.82	166.67
NSR	67	1.76	5.88	7.03	15.49	28.24	40.90	59.55	99.26	136.19
	72	1.66	3.74	7.69	12.22	24.24	42.85	71.39	88.64	124.54
	77	2.09	3.54	8.44	12.86	24.41	37.37	61.28	84.64	135.94
NSI	67	4.53	5.66	10.28	20.29	29.33	44.88	62.21	104.90	145.35
	72	2.84	5.02	11.15	16.34	29.69	45.83	81.83	102.88	157.06
	77	3.40	5.40	12.20	16.52	26.94	47.56	79.84	98.10	156.53
Females										
Shale	67	2.65	4.56	5.41	11.08	15.80	23.70	43.54	73.99	128.07
	72	2.04	3.73	7.58	9.85	17.12	25.21	39.78	78.31	124.15
	77	2.15	3.26	8.18	11.73	18.75	23.72	40.85	60.86	102.60
NSR	67	2.72	1.92	4.49	7.88	15.48	20.72	42.54	57.61	117.34
	72	1.41	3.26	6.25	9.43	12.28	21.41	36.21	52.74	97.71
	77	1.22	4.25	5.55	6.64	11.77	21.46	39.33	52.28	104.89
NSI	67	2.19	5.09	8.05	9.90	15.88	22.19	42.23	75.55	121.25
	72	2.57	4.94	7.40	9.32	16.33	28.81	49.00	70.79	117.71
	77	2.81	3.31	5.95	11.18	15.73	24.83	44.45	70.19	107.76

Table A6.2 Cohort death rates for all cancer mortality.

Area	Pivotal Year	40-44	45-59	50-54	55-59	60-64	65-69	70-74	75-79	80-84
					Age Group					
Males										
Shale	57	7.25	16.60	26.30	51.29	89.37	87.09	153.04	145.75	249.22
	62	9.31	14.85	27.21	51.50	75.98	128.40	155.83	197.49	212.07
	67	6.51	10.44	36.30	49.67	78.99	154.34	138.82	229.70	225.35
	72	7.75	16.11	21.08	30.52	88.92	152.14	164.34	183.96	317.92
	77	4.38	20.76	32.91	58.21	79.71	111.53	156.56	267.80	246.38
NSR	57	5.60	16.56	23.95	54.27	60.11	103.66	88.50	137.30	127.39
	62	0.00	15.05	22.00	51.10	70.74	46.81	125.10	84.03	309.05
	67	3.92	10.13	25.10	58.74	61.67	110.29	123.20	263.99	155.64
	72	0.00	11.37	20.79	40.73	71.15	99.15	205.52	221.61	315.99
	77	7.85	11.80	16.55	42.28	56.34	117.72	175.07	170.70	250.00
NSI	57	7.71	11.03	29.55	48.49	42.77	96.32	129.69	152.47	216.35
	62	5.70	12.19	26.93	42.71	69.35	100.51	145.99	137.14	292.06
	67	2.45	10.68	32.70	57.99	90.36	110.27	152.41	200.98	106.59
	72	8.74	11.51	27.28	42.33	78.34	114.16	177.53	202.16	334.57
	77	4.12	9.54	35.20	39.83	69.12	142.83	166.83	209.38	223.61
Females										
Shale	57	2.91	16.44	16.61	32.48	50.76	63.21	91.62	105.34	111.73
	62	0.79	18.07	28.09	45.51	60.24	64.37	93.04	122.62	169.25
	67	1.61	16.91	27.07	21.01	33.37	63.19	82.08	80.43	96.05
	72	2.22	11.94	31.58	39.41	54.39	60.23	82.50	74.79	170.07
	77	9.05	13.05	33.85	40.61	71.44	66.96	108.27	110.65	99.93
NSR	57	0.55	10.74	26.58	42.04	49.30	58.45	80.40	98.92	157.89
	62	1.69	10.01	27.03	29.84	80.17	75.54	105.57	152.74	171.23
	67	5.52	4.26	23.61	34.15	56.56	44.89	86.04	75.45	91.26
	72	7.84	18.90	29.29	38.58	40.94	53.54	70.09	63.93	79.76
	77	5.44	23.43	24.50	17.95	45.44	70.73	110.13	84.32	157.73
NSI	57	9.87	18.20	21.07	41.30	48.81	67.52	58.61	111.63	109.99
	62	8.76	13.39	16.57	28.00	68.38	66.61	72.17	105.91	182.45
	67	7.65	20.14	35.14	27.78	45.57	46.72	76.19	109.89	127.63
	72	0.72	17.49	23.53	35.68	34.71	64.19	97.62	98.16	161.99
	77	3.04	17.56	23.57	40.66	51.19	67.71	99.96	98.06	1 6.12

Table A6.3 Cohort death rates for bladder cancer.

Area	Pivotal Year	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
						Age Group				
Males										
Shale	57	0.00	0.00	0.00	0.00	0.00	3.79	19.13	24.29	31.15
	62	0.00	0.00	0.00	0.00	0.00	7.55	5.37	0.00	16.31
	67	0.00	0.00	3.63	0.00	2.39	9.65	9.57	8.20	14.08
	72	0.00	0.00	3.24	0.00	6.20	5.53	4.11	22.08	28.90
	77	0.00	0.00	0.00	0.00	3.80	2.37	3.33	12.17	28.99
NSR	57	2.80	0.00	0.00	0.00	4.29	18.29	0.00	0.00	0.00
	62	0.00	0.00	0.00	0.00	0.00	5.85	7.82	0.00	0.00
	67	0.00	0.00	0.00	0.00	0.00	0.00	13.69	0.00	38.91
	72	0.00	1.62	2.08	0.00	5.27	7.08	16.22	0.00	0.00
	77	0.00	1.47	0.00	3.52	0.00	5.89	12.51	0.00	46.87
NSI	57	0.00	0.00	0.00	1.43	1.86	0.00	7.01	5.26	0.00
	62	0.00	1.11	0.00	0.00	1.78	2.45	10.95	0.00	35.05
	67	0.00	1.07	0.00	6.04	1.48	5.80	6.22	9.80	0.00
	72	0.00	0.00	0.00	3.53	0.00	0.00	13.87	17.97	9.29
	77	0.00	0.00	2.35	1.17	5.64	11.36	11.92	3.88	0.00
Females										
Shale	57	0.00	0.00	0.00	0.00	5.34	0.00	4.58	0.00	0.00
	62	0.00	1.81	0.00	0.00	5.02	3.22	4.43	6.81	0.00
	67	0.00	0.00	0.00	0.00	2.22	2.63	7.14	5.36	21.34
	72	0.00	0.00	0.00	1.64	0.00	6.69	2.95	4.40	0.00
	77	0.00	0.00	0.00	0.00	0.00	5.74	2.46	0.00	6.66
NSR	57	0.00	0.00	0.00	0.00	0.00	0.00	6.18	0.00	0.00
	62	0.00	0.00	0.00	2.98	3.49	0.00	0.00	0.00	0.00
	67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	77	0.00	0.00	0.00	0.00	2.07	4.88	0.00	0.00	0.00
NSI	57	0.00	0.00	0.00	1.42	0.00	2.18	0.00	0.00	9.17
	62	0.00	0.00	1.18	0.00	0.00	0.00	2.67	0.00	0.00
	67	0.00	0.00	2.27	1.21	1.38	0.00	2.18	3.43	12.76
	72	0.00	0.00	0.00	0.00	0.00	4.48	0.00	2.97	0.00
	77	0.00	0.00	1.12	1.13	0.00	0.00	7.14	5.16	9.13

Table A6.4 Cohort death rates for respiratory cancer.

Area	Pivotal Year	Age Group 40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
Males										
Shale	57	1.81	7.38	8.09	18.65	49.31	26.51	28.69	24.29	15.58
	62	3.72	5.57	13.60	17.91	43.83	33.99	53.73	26.93	0.00
	67	0.00	1.74	7.26	35.76	45.48	77.17	52.66	65.63	28.17
	72	2.58	4.39	8.11	16.16	43.42	88.52	61.63	51.51	57.80
	77	2.19	12.98	17.17	29.11	39.86	49.83	73.28	97.38	43.48
NSR	57	0.00	8.28	17.96	28.94	12.88	30.49	44.25	22.88	21.23
	62	0.00	2.51	5.50	19.16	41.61	29.26	31.27	12.00	66.23
	67	0.00	2.03	10.04	21.36	35.70	55.15	41.07	73.92	19.46
	72	0.00	1.62	8.32	10.72	23.72	42.49	91.94	73.87	74.35
	77	0.00	2.95	8.28	15.85	25.82	50.03	83.37	56.90	62.50
NSI	57	2.20	3.31	12.31	27.10	20.45	37.05	28.04	15.77	48.08
	62	1.14	3.32	9.37	14.68	37.34	31.87	47.45	28.57	11.68
	67	4.53	1.07	18.69	28.99	44.44	56.10	62.21	68.63	29.07
	72	5.46	6.28	13.05	17.64	32.99	63.04	94.31	62.89	83.64
	77	0.00	2.12	15.25	17.57	35.27	60.06	71.50	69.79	62.61
Females										
Shale	57	0.00	0.00	0.00	0.00	2.67	6.65	9.16	14.04	13.97
	62	0.00	0.00	2.01	4.33	2.51	6.44	0.00	0.00	0.00
	67	0.00	0.00	0.00	1.91	0.00	2.63	7.14	0.00	0.00
	72	2.72	1.49	3.16	4.93	4.03	4.46	8.84	8.80	8.50
	77	1.13	1.31	5.64	10.53	14.29	9.57	17.22	13.83	6.66
NSR	57	0.00	0.00	2.95	0.00	3.79	0.00	12.37	8.99	17.54
	62	4.68	0.00	0.00	0.00	6.97	8.39	5.87	0.00	0.00
	67	3.88	0.00	0.00	5.25	0.00	0.00	0.00	0.00	13.04
	72	0.00	1.72	3.91	6.43	12.04	11.27	7.79	5.33	0.00
	77	0.00	0.00	4.90	3.59	10.33	7.32	15.73	4.22	7.89
NSI	57	1.10	0.00	0.00	2.85	1.68	6.53	2.79	4.65	0.00
	62	2.19	2.23	2.37	1.33	3.18	6.06	2.67	0.00	0.00
	67	1.09	1.06	1.13	3.62	5.52	5.01	2.18	3.43	6.38
	72	0.00	6.17	1.12	2.30	5.14	7.46	7.81	14.87	5.40
	77	2.01	3.10	6.73	9.04	7.49	8.46	8.93	5.16	4.57

Table A6.5 Cohort death rates for 'other genito-urinary' cancer.

Area	Pivotal Year	Age Group 40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
Males										
Shale	57	0.00	0.00	2.02	0.00	0.00	7.57	23.91	40.49	62.31
	62	0.00	0.00	0.00	0.00	5.84	3.78	10.75	35.91	81.57
	67	1.63	0.00	1.82	3.97	2.39	6.43	4.79	41.02	42.25
	72	0.00	2.93	0.00	0.00	4.14	8.30	16.43	22.08	115.61
	77	0.00	0.00	0.00	6.47	3.80	4.75	16.66	54.78	28.99
NSR	57	0.00	0.00	0.00	0.00	0.00	12.20	0.00	34.32	42.46
	62	0.00	0.00	0.00	3.19	4.16	0.00	7.82	36.01	66.23
	67	0.00	0.00	0.00	2.67	0.00	4.60	6.84	31.68	19.46
	72	0.00	0.00	0.00	0.00	10.54	10.62	10.82	36.93	37.17
	77	0.00	0.00	0.00	1.76	2.35	11.77	12.51	14.22	31.25
NSI	57	0.00	0.00	0.00	0.00	1.86	4.94	3.51	26.29	24.04
	62	0.00	0.00	0.00	0.00	0.00	2.45	7.30	11.43	35.05
	67	0.00	0.00	2.34	1.21	0.00	11.61	9.33	4.90	19.38
	72	1.09	0.00	0.00	3.53	4.12	5.11	11.10	13.48	65.06
	77	0.00	1.06	0.00	0.00	8.46	6.49	9.53	31.02	44.72
Females										
Shale	57	1.84	1.83	6.23	6.96	2.67	3.33	0.00	21.07	13.97
	62	1.80	0.00	4.01	2.17	2.51	6.44	13.29	27.25	28.21
	67	0.00	3.38	1.80	3.82	8.90	2.63	3.57	0.00	10.67
	72	1.36	1.49	4.74	4.93	4.03	6.69	8.84	4.40	17.01
	77	1.13	1.31	5.64	6.02	7.14	5.74	12.30	6.92	0.00
NSR	57	2.57	5.37	0.00	9.70	3.79	17.99	6.18	0.00	0.00
	62	0.00	0.00	0.00	2.98	17.43	12.59	35.19	8.98	34.25
	67	0.00	2.13	2.36	5.25	11.91	6.91	4.78	0.00	13.04
	72	1.57	1.72	5.86	6.43	2.41	5.64	0.00	5.33	0.00
	77	0.00	1.46	0.00	1.80	0.00	9.76	12.59	4.22	23.66
NSI	57	1.10	2.28	1.24	2.85	6.73	4.36	5.58	13.95	9.17
	62	0.00	1.12	1.18	2.67	7.95	2.02	5.35	4.41	8.69
	67	1.09	6.36	0.00	2.42	8.29	5.01	4.35	17.17	19.14
	72	0.00	2.06	3.36	3.45	2.57	7.46	11.71	11.90	16.20
	77	0.00	1.03	0.00	4.52	6.24	9.87	8.93	12.90	13.70

Table A6.6 Cohort death rates for ischaemic heart disease.

Area	Pivotal Year	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
					Age Group					
Males										
Shale	67	13.02	22.62	47.20	61.59	117.28	183.28	220.20	344.54	338.03
	72	14.22	29.30	51.89	59.24	138.54	149.38	209.53	375.28	375.72
	77	12.04	24.66	61.53	72.77	117.67	201.71	226.52	395.62	579.71
NSR	67	5.88	16.21	27.61	42.72	116.85	160.85	171.12	274.55	466.93
	72	7.56	16.25	35.35	49.30	86.96	166.43	232.56	277.01	501.86
	77	5.23	19.17	46.35	52.84	96.24	123.60	212.59	298.72	437.50
NSI	67	13.58	24.56	37.37	78.52	96.28	148.96	171.07	308.82	455.43
	72	7.65	24.07	36.77	61.14	101.70	146.53	246.88	300.99	390.33
	77	17.50	29.67	53.97	74.97	118.49	172.05	271.69	228.77	411.45
Females										
Shale	67	1.66	5.07	7.22	26.74	40.04	65.82	110.64	182.31	288.15
	72	4.07	4.48	11.05	14.78	42.30	66.92	126.69	228.77	272.11
	77	1.13	2.61	15.51	24.07	46.44	63.13	110.73	200.55	253.16
NSR	67	3.88	0.00	7.08	21.01	32.75	69.06	100.38	150.89	286.83
	72	1.57	5.15	9.76	25.72	28.90	70.44	112.93	170.48	209.37
	77	0.00	1.46	13.07	19.75	24.78	73.17	125.87	143.34	291.80
NSI	67	4.37	7.42	15.87	26.57	45.57	65.08	106.66	223.21	268.03
	72	4.29	8.23	11.21	25.32	55.28	82.10	142.52	202.26	307.78
	77	2.01	2.07	10.10	30.49	39.95	83.23	128.53	190.97	264.84

Table A6.7 Cohort death rates for cerebrovascular disease.

Area	Pivotal Year	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
Males										
Shale	67	1.63	0.00	9.08	21.86	33.51	90.03	90.95	254.31	239.44
	72	0.00	2.93	12.97	23.34	26.88	69.16	110.93	169.24	274.57
	77	1.09	5.19	2.86	4.85	28.47	54.58	86.61	146.07	246.38
NSR	67	0.00	6.08	0.00	16.02	38.95	32.17	130.05	200.63	233.46
	72	1.51	3.25	4.16	8.57	18.45	60.20	81.12	120.04	185.87
	77	0.00	1.47	1.66	5.28	30.52	55.92	50.02	113.80	312.50
NSI	67	0.00	2.14	7.01	12.08	32.59	65.78	96.42	156.86	358.53
	72	2.18	3.14	10.68	23.52	30.24	76.67	122.05	188.68	315.99
	77	1.03	1.06	3.52	10.54	32.44	53.56	142.99	166.73	241.50
Females										
shale	67	4.98	8.45	10.83	21.01	33.37	31.60	92.79	193.03	384.20
	72	1.36	7.46	11.05	14.78	24.17	44.61	76.61	180.38	323.13
	77	3.39	5.22	7.05	22.56	25.00	34.44	95.96	117.57	253.16
NSR	67	1.94	2.13	9.45	10.51	32.75	34.53	90.82	185.19	338.98
	72	1.57	1.72	7.81	6.43	21.68	30.99	54.52	111.88	279.16
	77	2.72	5.86	8.17	7.18	18.59	29.27	50.35	160.20	252.37
NSI	67	0.00	7.42	5.67	10.87	24.86	43.38	106.66	175.14	306.32
	72	0.00	4.12	12.33	12.66	15.43	46.28	109.33	169.54	345.57
	77	1.00	3.10	8.98	12.42	31.21	35.27	101.75	175.48	246.58

Table A6.8 Schematic diagram of cohort identification.

Area	Pivotal Year	40-44	45-59	50-54	55-59	60-64	65-69	70-74	75-79	80-84
xxxxx	57	18	17	16	15	14	13	12	11	10
	62	19	18	17	16	15	14	13	12	11
	67	20	19	18	17	16	15	14	13	12
	72	21	20	19	18	17	16	15	14	13
	77	22	21	20	19	18	17	16	15	14

APPENDIX 7

Classification of Occupations for the Case-control Study

The occupational job codes were classified into four categories: coalmining, probable shale occupations, possible shale occupations and other. This was done by selecting from the coding revisions those jobs which were thought likely to refer to shale-related work. This information was supplemented by a list of the codes from the death certificates of the men in the Provident Fund study (i.e. known shale workers), from which further shale-related job names and codes were extracted. As a result the four groups were defined as follows:

(i) coalmining - all workers in coalmines;
(ii) probable shale - all workers in mines other than coal,
chemical production process workers,
labourers in chemical and allied trades;
(iii) possible shale - stationary engine drivers,
boiler firemen and stokers;
(iv) other - all jobs not included in (i), (ii) and (iii).

Table A7.1 gives the numbers and percentages of men working in each of the occupational groups in the shale study area. The area has been divided into 'no shale rural', 'no shale industrial' and 'shale' because the distribution of occupational groups differs between the three areas. The total frequencies for the whole study area are also given, as are those for the PF men for comparison. The four revisions are kept separate throughout.

Examination of the trends over time in this Table reveal patterns which would be expected if the classification was reasonably accurate. The percentage of men in each area working in probable and possible shale-related occupations falls steadily over revisions, with a corresponding rise in the number in 'other' non-shale jobs. This is consistent with the closure of the shale industry in 1962 since men dying in the later years would be more likely to have worked elsewhere than in shale for their last known occupation. Furthermore the proportion of men in the shale occupation groups is consistently highest in the 'shale' activity area. The trends for men in the study area are similar to those for the PF men but with fewer men overall working in the shale categories. The largest proportions of coalminers are based in 'no shale industrial'. The PF men are unusual in that they show a slight increase in the number of coalminers in the 1980s, compared to a decrease in the study area overall. This may be due to more PF men entering the coal industry after the shale industry closed than was the case in the area generally.

Table A7.1 Distribution of occupational groupings for RG coded 'occupation at death' for cases and controls and Provident Fund men.

Occupational group		Year of occupational coding revision 1950	1960	1970	1980
Coalmining	P.F.	3 (4%)	34 (5%)	43 (4%)	14 (8%)
	Rural	1 (1%)	5 (2%)	1 (1%)	2 (3%)
	Industrial	76 (27%)	187 (30%)	170 (24%)	31 (19%)
	Shale	27 (14%)	57 (14%)	45 (9%)	10 (7%)
	Total study area	104 (18%)	249 (19%)	216 (14%)	43 (11%)
Probable Shale	P.F.	36 (53%)	296 (43%)	376 (37%)	43 (24%)
	Rural	12 (11%)	23 (9%)	23 (6%)	1 (1%)
	Industrial	5 (2%)	11 (2%)	19 (3%)	4 (3%)
	Shale	55 (28%)	74 (18%)	53 (10%)	7 (5%)
	Total study area	72 (12%)	108 (8%)	95 (6%)	12 (3%)
Possible Shale	P.F.	8 (12%)	55 (8%)	32 (3%)	4 (2%)
	Rural	0 (0%)	6 (2%)	7 (2%)	0 (0%)
	Industrial	11 (4%)	11 (2%)	13 (2%)	1 (1%)
	Shale	13 (7%)	13 (3%)	13 (3%)	1 (1%)
	Total study area	24 (4%)	30 (2%)	33 (2%)	2 (1%)
Other	P.F.	21 (31%)	305 (44%)	572 (56%)	131 (75%)
	Rural	99 (88%)	221 (87%)	324 (91%)	74 (96%)
	Industrial	186 (67%)	424 (67%)	493 (71%)	124 (78%)
	Shale	101 (52%)	273 (65%)	415 (79%)	119 (87%)
	Total study area	386 (66%)	918 (70%)	1232 (78%)	317 (85%)

P.F. = Provident Fund members.
Percentages are of the total number of men included in each study area.

APPENDIX 8

Quantification of Net Out-migration 1911-31

A8.1 Calculation of Net Out-migration

Migration from the 'High Shale', 'Low Shale' and 'No Shale Industrial' areas between 1911 and 1931 was calculated from the census populations of 1911, 1921 and 1931 and the numbers of deaths occurring from 1911-21 and 1921-31. The population data used were in 10-year age groups from 5-14,15-24.......65-74 and the numbers of deaths were in 5-year age groups. The number of deaths in any specific 10-year age group in 1911 during the period 1911-1921 was calculated as follows; using the 1911 age group 15-24 as an example:

```
Deaths 15-24 (1911-21) => 1911 = 2/3 (D 15-19 + D 20-24) *1
                         +1912 = 4/5 D 15-19 + D 20-24 + 1/5 D 25-29
                         +1913 = 3/5 D 15-19 + D 20-24 + 2/5 D 25-29
                         +1914 = 2/5 D 15-19 + D 20-24 + 3/5 D 25-29
                         +1915 = 1/5 D 15-19 + D 24-29 + 4/5 D 25-29
                         +1916 = D 20-24 + D 25-29
                         +1917 = 4/5 D 20-24 + D 25-29 + 1/5 D 30-34
                         +1918 = 3/5 D 20-24 + D 25-29 + 2/5 D 30-34
                         +1919 = 2/5 D 20-24 + D 25-29 + 3/5 D 30-34
                         +1920 = 1/5 D 20-24 + D 25-29 + 4/5 D 30-34
                         +1921 = 1/2 (D 25-29 + D 30-34)           *2
```

*1: 1911 census occurred in April so deaths calculated for remaining 8 months = 2/3 of the year.

*2: 1921 census occurred in June so deaths calculated for first half of the year.

This calculation assumes that the deaths occur evenly throughout the year and throughout each 5-year age group. The net out-migration for each age group for the first period was defined as

$$m = pop(1911) - pop(1921) - deaths(1911\text{-}21)$$

and for the second period as

$$m = pop(1921) - pop(1931) - deaths(1921\text{-}31)$$

and the percentage out-migration per age group was

$$\%m = m/pop(1911) * 100 \text{ and}$$
$$\%m = m/pop(1921) * 100$$

for the two periods. The results from these calculations are given in Tables A8.1.

A8.2 Trends in Net Out-Migration

In all areas and periods (except Low Shale 1921-31) the pattern of net female out-migration is very high for those 5-14 at the beginning of the period (15-24 at the end). In the next age group net out-migration is much reduced - in the first period and in all areas being negligible. This reflects the labour patterns for young girls who generally went into 'service' on leaving school at 14. Most of this 'service' was in large country houses outwith the area, in Fife, Perth, or most commonly Edinburgh. By their early to mid twenties many of these girls came back to be married to men from their village. At the same time other women were being brought in from other areas – explaining the much lower levels of out–migration in this age group.

Out–migration was much higher in the 1920s than in the 1910s. This reflects the depression of the time. It exists even for men for whom the First World War would also have been reflected as migration because deaths to soldiers were not linked to their home areas, thus giving high levels of out–migration from 1914–18. Net out–migration, especially for men is much higher in the shale areas – where much of the industry closed down – than in the coal areas where the strike affected the population in 1926 but did not lead to permanent migration. In the shale areas many people left to go to Canada, the United States and Australia.

Table A8.1 Net out-migration 1911-21 and 1921-31 for each shale activity area (percentage of original cohort not present or dead 10 years later).

	1911-21		1921-31	
	male	female	male	female
High Shale				
5-14	12.1	30.7	24.1	40.1
15-24	20.5	-0.8	36.1	19.6
25-34	16.2	11.6	21.4	18.6
35-44	5.5	6.2	16.5	13.9
45-54	6.2	8.6	16.5	13.7
55-64	5.8	3.9	6.9	3.0
65-74	7.9	2.9	7.9	1.4
Low Shale				
5-14	4.4	15.6	30.0	17.6
15-24	10.8	2.7	25.6	22.9
25-34	12.8	9.9	15.5	23.0
35-44	3.8	7.9	11.7	9.6
45-54	3.9	8.9	14.1	0.9
55-64	2.9	0.0	6.8	-5.1
65-74	4.6	4.1	-1.4	12.3
No Shale Industrial				
5-14	4.8	21.9	10.4	31.9
15-24	18.3	-0.7	18.7	10.7
25-34	12.1	5.3	12.5	7.4
35-44	8.7	5.0	9.4	8.9
45-54	8.5	9.7	8.3	5.7
55-64	11.4	1.5	3.9	-1.8
65-74	7.5	-1.6	-6.3	5.9