A STUDY OF THE INCIDENCE OF CANCER OF THE LUNG AND LARYNX

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(With 5 Graphs in the Text)

CONTENTS

I. Material examined

The data given below are derived from an examination of the death certificates of cases of cancer of the lung and of the larynx in males from England and Wales for the years 1921–32 inclusive. The whole number of certificates examined individually was 18,275 (lung 8808, larynx 9472), while the annual total figures for cases in women have been utilised for comparison. The investigation was carried out on the general lines followed in an earlier study of the occupational incidence of cancer of the bladder and prostate (Henry, Kennaway and Kennaway, 1931).

The chief objects of the enquiry were to ascertain (1) whether cancer of the lung showed any special incidence upon particular occupations and especially upon those (*loc. cit.*) which involve an increased liability to cancer of the bladder, (2) whether the great increase in deaths attributed to cancer of the lung (from 361 deaths in 1921 to 1553 in 1932, for males) indicates a real increase in the prevalence of this form of cancer. The figures for cancer of the larynx serve as a basis of comparison with those for cancer of the lung, in that the larynx is a part of the same (respiratory) tract which is more accessible to inspection and is not examined by diagnostic methods which have changed greatly in recent years. The death certificates of persons under 20 years of age

https://doi.org/10.1017/S0022172400043618 Published online by Cambridge University Press

were omitted, as the investigation was concerned primarily with the effect of occupation.

II. SOURCES OF ERROR IN STATISTICAL WORK ON DEATH CERTIFICATES

The use of death certificates for statistical purposes is liable to errors which are inherent in the nature of the material and cannot be wholly eliminated. One must either recognise and admit these errors and correct them in any way possible, or abandon any attempt to obtain information from these data.

(1) *Correction for period between census.* In order to ascertain the incidence of cancer upon any one occupation one must know the number of persons following that occupation. This is learned from the census returns. A census was taken in 1921 and in 1931, and the certificates considered here are those of the 12 years 1921–32 inclusive. To compensate for the asymmetrical position of the two census years in the 12-year period the following formula, for which we are indebted to the General Register Office, was used. If p_{21} = the 1921 census population and p_{31} that of the 1931 census, the population required is assumed to be given by $\frac{11}{2}(p_{21}+p_{31})+p_{31}+\frac{1}{10}(p_{31}-p_{21})$, which is equivalent to $\frac{5{\cdot}4p_{21}+6{\cdot}6p_{31}}{12}$. This correction was applied to the two figures for the population of each of seven age groups (20–24, 25–34, 35–44, 45–54, 55–64, 65–69, 70 and upwards) of each of the sixty-three occupations examined in detail (Tables II, III, and X).

(2) *Sampling error.* In some of the most interesting occupations from the present standpoint (*e.g.* chimney sweeping, tar distilling) a few thousand men only are employed, and these will yield but very few cases of cancer of any one organ even if the incidence is high. Hence the sampling error will be very large even over the period studied here of 12 years. The figures given in Table XV show that in the occupations employing rather small numbers, data from a considerable number of years are necessary to establish any reliable value for comparative incidence. Similar, though less numerous, fluctuations are seen even in the much larger groups of agricultural workers in the figures for cancer of the lung (Fig. 5, 1924–5–6).

The foregoing considerations apply to death certificates in bulk.

(3) *Duration of employment.* The individual entry in the death register does not give, and is not intended to give, any information about the length of time during which the deceased followed the occupation named, nor about the nature or duration of any previous employment; the uncertainty could be removed only by enquiry into each individual case. This matter was discussed fully by Henry, Kennaway and Kennaway (1931).

(4) *Unemployment*, or intermittent work, in any occupation must tend to obscure the influence of that occupation, if any, upon the incidence of cancer.

(5) *Incorrect diagnosis* is of course a source of error in these, as in all other, medical data. In the case of death certificates received in bulk, perhaps some

years after the dates of the deaths recorded, one can do nothing but exclude any certificate of which the wording suggests (1) that the cause of death did not come within the category under examination, or (2) that the diagnosis was uncertain or ill-founded[1] (see next section). When this has been done, it must be assumed that the remaining certificates are correct if any use is to be made of the material.

III. Death certificates taken for examination

The material utilised in this paper has been restricted as far as possible to cases of primary malignant growth of the lung, and of the larynx. The forms of words in the certificates taken for examination, and in those rejected, may be stated thus:

Cancer of lung

(*a*) *Retained*

Cancer, carcinoma, or sarcoma of lung, bronchus, pleura, root of lung, hilum of lung, lung and mediastinum, or lung and pleura. Pulmonary, or bronchial, cancer, carcinoma, or sarcoma. Cancerous pleurisy.

(*b*) *Rejected*

Any new growth of mediastinum, of mediastinal or of bronchial glands. New growths of chest or thorax. Peribronchial new growth. Any new growth qualified by "probable", "doubtful" or "query".

Where another organ is mentioned, in addition to the lung, as the site of new growth, the practice has been to retain those cases where this organ is unlikely to be the primary site (*e.g.* cancer of lung and brain, or of lung and liver) and to reject the rest (*e.g.* sarcoma of arm and lung, sarcoma of lung and testicle, cancer of lung and oesophagus).

Cancer of larynx

(*a*) *Retained*

The category of cancer of the larynx in the tabulation used in the General Register Office includes malignant growths of which the situation is described by the following terms:

Aryteno-epiglottidean folds	Post-cricoid, retro-cricoid
Arytenoid glands and cartilage	Pyriform fossa. Sinus pyriformis
Cricoid	Thyroid cartilage
Epiglottis	Vallecula epiglottica
Glosso-epiglottic fold	Vocal cords
Glottis	Trachea, windpipe.

All these were retained with the exception of vallecula.

[1] Such certificates are made the subject of individual enquiry by the General Register Office.

(*b*) *Rejected*

Any new growth qualified by "probable", "doubtful", or "query".

Some cases of which the nature is doubtful (*e.g.* "tumour of cricoid cartilage and thyroid gland").

IV. AUTOPSIES

The opinion is sometimes expressed that statistics of lung cancer are of no value which comprise any cases where no autopsy has been made. Table I shows the numbers of autopsies recorded in the death certificates discussed

Table I. *Autopsies*

Year	I No P.M.	II Inquest, no P.M.	III Sum of I and II	IV P.M.	V Inquest and P.M.	VI Coroner's P.M. no inquest	VII Sum of IV, V and VI	Total
				Cancer of lung				
1921	279	5	284	50	3	—	53	337
1922	353	3	356	36	2	—	38	394
1923	331	2	333	48	4	—	52	385
1924	370	4	374	87	6	—	93	467
1925	384	3	387	98	5	—	103	490
1926	460	4	464	84	5	—	89	553
1927	496	3	499	135	10	3	148	647
1928	532	3	535	231	16	9	256	791
1929	581	2	583	211	28	11	250	833
1930	736	2	738	270	18	8	296	1034
1931	952	1	953	360	17	14	391	1344
1932	1095	2	1097	395	18	23	436	1533
	6569	34	6603	2005	132	68	2205	8808
				Cancer of larynx				
1921	615	4	619	21	4	—	25	644
1922	668	2	670	13	1	—	14	684
1923	679	2	681	22	1	—	23	704
1924	688	3	691	26	4	—	30	721
1925	773	1	774	28	4	—	32	806
1926	795	4	799	31	5	—	36	835
1927	766	2	768	39	1	2	42	810
1928	753	4	757	69	5	3	77	834
1929	753	3	756	66	4	2	72	828
1930	776	2	778	80	5	1	86	864
1931	782	5	787	67	5	6	78	865
1932	797	—	797	70	7	3	80	877
	8845	32	8877	532	46	17	595	9472

here (*i.e.* after the exclusions stated in the preceding section). The cases are classified as follows:

No P.M.: (1) No P.M.
(2) Inquest. No P.M.

P.M.: (3) P.M.
(4) Inquest and P.M.
(5) Coroner's P.M. without inquest.

https://doi.org/10.1017/S0022172400043618 Published online by Cambridge University Press

The table shows that:

(1) The number of autopsies has increased much more in the lung series than in the larynx series:

	Number of autopsies per annum	
	Average of 1921–2–3	1932
Cancer of lung	48	436
Cancer of larynx	21	80

(2) A high proportion of cases thought to have died of cancer of the lung is now subjected to autopsy (in 1932, 436 autopsies in 1533 cases, or 28 per cent.). Cf., in the larynx series, autopsies about 9 per cent. latterly.

(3) The number of autopsies alone on lung cases in 1932 (436) is considerably greater than the whole number of cases recorded in earlier years (337 in 1921).

(4) The increase in the recorded cases of lung cancer is not nearly accounted for by the increase of data obtained by autopsy. Thus all the cases of 1921 plus the autopsies of 1932 ($337+436=773$) is only one-half of the number (1533) of cases stated to occur in 1932.

(5) For some reason the number of autopsies in larynx cases shows an abrupt rise in 1928.

V. Method of calculation of ratios

The incidence of cancer of the lung and larynx upon various occupations was estimated in the manner described by Henry, Kennaway and Kennaway (1931) upon cancer of the bladder and prostate. In judging of the occupational incidence of any form of cancer it is of course necessary to correct for age distribution, for an occupation employing a large proportion of older men will yield more cases of cancer apart from any aetiological factor. The census returns give the age distribution in 5- and 10-yearly periods, of the whole population of males, and also of those following each one of the recognised occupations, at the time of the census. The number of cases of cancer of the lung and of the larynx occurring in the whole male population in each of these age groups during the years in question was obtained from material at the General Register Office. The comparison of the various occupations with the general population is then a sum in proportion. An example of the method is given in Table II: the populations stated are taken from the 1921 and 1931 census in the manner described above (p. 237).

Table II shows, for example, that all the 2,226,511 males in England and Wales between the ages of 45 and 55 produced 2418 fatal cases of cancer of the lung in the 12 years 1921–32. The 60,917 farmers in this age group should, at this rate, give 66·15 cases. One proceeds in this way through each age group and adds up the total cancers of the lung for a hypothetical general population of the number and age distribution of farmers, obtaining a total of 286·164.

But the actual number given by the death certificates of farmers is 153. The ratio for farmers is therefore $\frac{153 \times 100}{286{\cdot}164} = 53{\cdot}4$.

Table II. *Cancer of lung*

	Age group							Total aged 20 and upwards	Total registered deaths	Ratio of registered to 100 calculated deaths
	20–24	25–34	35–44	45–54	55–64	65–69	70 and upwards			
All males:										
Population	1,586,301	2,863,831	2,505,164	2,226,511	1,593,309	520,097	621,072	11,916,285	—	—
Deaths, cancer of lung	73	283	1,019	2,418	2,951	1,046	1,015	—	8,805*	100
Farmers:										
Population	5,750	35,233	54,625	60,917	54,092	21,104	31,459	263,180	—	—
Deaths, cancer of lung	0·264	3·48	22·22	66·15	100·2	42·44	51·41	286·164	153	53·4

* The discrepancy between the total given here (8805) and the total given elsewhere of certificates examined (8808) is due to 3 certificates in which no age was given.

The high figure for cancer of the lung in stockbrokers (Table X) may be used to illustrate the effect of single deaths upon the ratio in the smaller groups. The actual number of deaths from cancer of the lung is 14 (ratio 187·2); other totals would give ratios as shown below.

Deaths	Ratio	Deaths	Ratio
14	187·2	11	147·0
13	173·9	10	133·7
12	160·0	9	120·4

VI. COMPARATIVE INCIDENCE UPON VARIOUS OCCUPATIONS

The sixty-three occupations named in Tables III, IV and X employed during the period in question 3,565,268 out of the 11,916,285 males aged 20 and upwards (census of 1921 and 1931), and they include most of the men engaged in the two largest industries in the country, namely agriculture and coal-mining. The tables include 2249 out of the 8808 cases of cancer of the lung, and 2520 out of the 9472 cases of cancer of the larynx, occurring in the whole population in question.

Tables III and IV show the data referring to the occupations which have been studied in detail. In Table III the occupations are arranged in the order of magnitude of the ratio for cancer of the lung, and in Table IV in the corresponding order for cancer of the larynx. The population engaged in each occupation, and the numbers of calculated, and of actual, deaths which are required for the estimation of the ratios (see Table II) are included. The number of deaths in each year (1921–32) in each of these occupations is given in Table XV.

(1) *Agriculture.* A group of open-air occupations (gardeners, farmers, agricultural labourers, including shepherds, farm bailiffs and foremen), which together include nearly 918,000 men has 395 cancers of the lung and 520 cancers of the larynx. This group shows very low ratios for lung (from 26 to 58) and low ratios for larynx (41 to 75). In this open-air class the highest figure for

Table III

	Estimated population (1921 and 1931 Census)	Calculated deaths		Total registered deaths		Ratio of registered 100 calculated deaths	
		Lung	Larynx	Lung	Larynx	Lung	Larynx
All males aged 20 and upwards	11,916,285	—	—	8808	9472	—	—
Labourers patent fuel works	847*	0·46	—	2	—	433	—
Gas stokers and coke-oven chargers	12,818	10·8	10·7	37	20	342	186
Gas-works managers	1,303*	1·23	1·32	3	1	244	76
Metal grinders	15,220	8·3	7·1	19	10	229	141
Paviours, street masons, concretors, asphalters	7,419	5·7	5·8	12	9	209	154
Sandblasters	920	0·5	0·4	1	—	201	—
Gas-works foremen and inspectors	5,443	5·1	5·3	10	4	197	76
Tobacco manufacturers	7,698*	4·6	4·6	9	3	196	65
Gas fitters	15,079	8·8	8·3	16	8	182	96
Tobacconists and their assistants	14,034	12·0	13·4	21	19	175	142
Mainly council labourers, road sweepers, and dustmen	39,455*†	39·2	45·3	68	78	173	172
Chimney sweeps	5,900	6·5	7·8	11	15	170	192
French polishers	17,783	11·4	11·1	19	15	167	135
Gas producermen	3,195	2·5	2·3	4	2	162	88
Gas-works labourers	33.394*	28·5	30·8	46	32	162	104
Potters; ware makers, casters and finishers	7,723	5·9	6·0	9	11	152	184
Stonemasons, cutters and dressers	37,177	35·5	40·7	53	51	149	125
Tanners, leather dressers, curriers, skilled workers	18,001	14·2	15·9	21	11	148	69
Drivers of horse-drawn vehicles	154,554	123	132	177	242	144	184
Motor drivers, goods and passengers	254,350	96·0	64·8	136	65	142	100
Cabinet makers	34,455	24·7	28·0	34	46	138	164
Blast furnace engine men	965*	0·74	0·76	1	—	134	—
Licensed victuallers	75,832	83·8	93·4	107	173	128	185
Painters	178,837	143	150	176	195	123	130
Grooms, horsekeepers	31,948	28·4	32·1	30	43	106	134
Stone miners and quarriers	28,474	21·0	21·8	22	16	105	73
Plumbers	49,050	31·3	31·1	33	36	105	116
Barmen	21,059	9·6	8·3	10	39	104	469
Printers	83,489	59·7	61·2	61	71	102	116

Table III (*continued*)

	Estimated population (1921 and 1931 Census)	Calculated deaths		Total registered deaths		Ratio of registered 100 calculated deaths	
		Lung	Larynx	Lung	Larynx	Lung	Larynx
Pottery, etc.: kiln and ovenmen, kiln setters and placers	12,188	8·2	7·7	8	9	98	116
Potters' mill workers; slip makers and arkmen	1,486	1·04	0·98	1	—	96	—
Professional men	105,097	7·7	7·4	104	112	94	84
Cellarmen	6,333	4·3	4·4	4	14	92	317
Bakers and pastry cooks	63,547	43·7	46·8	37	49	85	105
Blast furnacemen and labourers	9,391	7·2	7·4	6	3	84	40
Hairdressers	36,497	23·9	22·6	20	28	84	124
Lithographic and process engravers	5,704	3·6	3·6	3	3	83	84
Locomotive engine drivers, firemen and cleaners	87,514	54·1	54·3	41	30	76	55
Carpenters	210,431	169	194	123	159	73	82
Stationary engine and crane drivers	72,875	58·9	60·8	42	49	71	81
Coal miners—workers above ground	83,671	65·1	70·5	46	39	71	55
Coal miners—hewers	449,344	276	260	174	150	63	58
Gas-works engine and crane drivers	1,854	1·67	1·71	1	4	60	233
Gardeners	200,071	204	258	118	194	58	75
Farmers	263,180	286	354	153	143	53	40
Coal miners, making roads	62,155	54·8	60·0	29	27	53	45
Brick and plain tile makers	9,825	6·2	6·6	3	7	49	106
Cotton weavers	40,078*	27·8	29·4	13	22	47	75
Coal miners, other workers below ground	81,403	65·2	68·5	28	30	44	44
Coal miners, conveying material to the shaft	91,561	31·4	25·1	12	11	38	44
Agricultural labourers, including shepherds	434,390	351	418	119	174	34	41
Cotton spinners and piecers (mule, ring, cap or flyer)	38,817*	21·5	20·9	7	31	32	148
Cotton strippers, grinders, and card-room jobbers	5,242	3·4	3·3	1	2	30	60
Tar distillery workers and coke-oven workers	9,697	6·8	6·6	2	3	29	60
Farm bailiffs and foremen	20,270	18·8	20·3	5	9	26	44
Brick kiln and ovenmen	6,225	4·3	4·2	1	3	23	71
Total	3,565,268			2249	2520		

* In this occupation for the year 1931, the population includes the age group 18–24, the figure for the age group 20–24 not being available.

† Population is that from 1931 Census only.

Table IV

	Estimated population (1921 and 1931 Census)	Calculated deaths		Total registered deaths		Ratio of registered to 100 calculated deaths	
		Larynx	Lung	Larynx	Lung	Larynx	Lung
All males aged 20 and upwards	11,916,285	—	—	9472	8808	—	—
Barmen	21,059	8·3	9·6	39	10	469	104
Cellarmen	6,333	4·4	4·3	14	4	317	92
Gas-works engine and crane drivers	1,854	1·71	1·67	4	1	233	60
Chimney sweeps	5,900	7·8	6·5	15	11	192	170
Gas stokers and coke-oven chargers	12,818	10·7	10·8	20	37	186	342
Licensed victuallers	75,832	93·4	83·8	173	107	185	128
Potters; ware makers, casters and finishers	7,723	6·0	5·9	11	9	184	152
Drivers of horse-drawn vehicles	154,554	132	123	242	177	184	144
Mainly council labourers, road sweepers and dustmen	39,455*†	45·3	39·2	78	68	172	173
Cabinet makers	34,455	28·0	24·7	46	34	164	138
Paviours, street masons, concretors, asphalters	7,419	5·8	5·7	9	12	154	209
Cotton spinners and piecers (mule, ring, cap or flyer)	38,817*	20·9	21·5	31	7	148	32
Tobacconists and their assistants	14,034	13·4	12·0	19	21	142	175
Metal grinders	15,220	7·1	8·3	10	19	141	229
French polishers	17,783	11·1	11·4	15	19	135	167
Grooms, horse-keepers	31,948	32·1	28·4	43	30	134	106
Painters	178,837	150	143	195	176	130	123
Stonemasons, cutters and dressers	37,177	40·7	35·5	51	53	125	149
Hairdressers	36,497	22·6	23·9	28	20	124	84
Plumbers	49,050	31·1	31·3	36	33	116	105
Printers	83,489	61·2	59·7	71	61	116	102
Pottery, etc.: kiln and ovenmen, kiln setters and placers	12,188	7·7	8·2	9	8	116	98
Brick and plain tile makers	9,825	6·6	6·2	7	3	106	49
Bakers and pastry cooks	63,547	46·8	43·6	49	37	105	85
Gas-works labourers	33,394*	30·8	28·5	32	46	104	162
Motor drivers, goods and passengers	254,350	64·8	96·0	65	136	100	142

Table IV (*continued*)

	Estimated population (1921 and 1931 Census)	Calculated deaths		Total registered deaths		Ratio of registered to 100 calculated deaths	
		Larynx	Lung	Larynx	Lung	Larynx	Lung
Gas fitters	15,079	8·3	8·8	8	16	96	182
Gas producermen	3,195	2·3	2·5	2	4	88	162
Lithographic and process engravers	5,704	3·6	3·6	3	3	84	83
Professional men	105,097	7·4	7·3	112	104	84	94
Carpenters	210,431	194	169	159	123	82	73
Stationary engine and crane drivers	72,875	60·8	59·0	49	42	81	71
Gas-works foremen and inspectors	5,443	5·3	5·1	4	10	76	197
Gas-works managers	1,303*	1·32	1·23	1	3	76	244
Gardeners	200,071	258	204	194	118	75	58
Cotton weavers	40,078*	29·4	27·8	22	13	75	47
Stone miners and quarriers	28,474	21·8	21·0	16	22	73	105
Brick kiln and ovenmen	6,225	4·2	4·3	3	1	71	23
Tanners, leather dressers, curriers, skilled workers	18,001	15·9	14·2	11	21	69	148
Tobacco manufacturers	7,698*	4·6	4·6	3	9	65	196
Cotton strippers, grinders and card-room jobbers	5,242	3·3	3·4	2	1	60	30
Tar distillery workers and coke-oven workers	9,697	6·6	6·8	3	2	60	29
Coal miners, hewers	449,344	260	276	150	174	58	63
Coal miners, workers above ground	83,671	70·5	65·1	39	46	55	71
Locomotive engine drivers, firemen and cleaners	87,514	54·3	54·1	30	41	55	76
Coal miners, making roads	62,155	60·0	54·8	27	29	45	53
Farm bailiffs and foremen	20,270	20·3	18·8	9	5	44	26
Coal miners, persons conveying material to the shaft	91,561	25·1	31·4	11	12	44	38
Coal miners, other workers below ground	81,403	68·5	65·2	30	28	44	44
Agricultural labourers, including shepherds	434,390	416	351	174	119	41	34
Farmers	263,180	354	286	143	153	40	53
Blast furnacemen and labourers	9,391	7·4	7·2	3	6	40	84
Total	3,561,050			2520	2244		

* In this occupation, for the year 1931, the population includes the age group 18–24, the figure for the age-group 20–24 not being available.

† Population is that from 1931 Census only.

both lung and larynx is given by gardeners, and their figure for larynx (75) is considerably higher than the next lower figure in this group (44 for farm bailiffs and foremen); this difference one might perhaps associate with the fact that many gardeners live in or near large towns.

(2) *Coal-mining.* The chief coal-mining occupations (workers above ground, hewers, road-makers, persons conveying material to the shaft, other workers below ground) which employ nearly 770,000 men, show low ratios (from 38 to 71 for lung, and from 44 to 58 for larynx) which are very like those of the open-air group considered in the preceding paragraph.

These two industries (agriculture and coal mining) have also a low incidence of cancer of the bladder (Henry, Kennaway and Kennaway, 1931).

(3) *Exposure to road dust.* A group of open-air occupations, where there is exposure to the dust of roads, has rather high ratios for both lung and larynx, with the exception that motor drivers have a normal figure for larynx (Table V). Among motor drivers there will be a large number who have not followed this occupation for many years.

Table V. *Occupations with exposure to road dust*

	Ratio	
	Lung	Larynx
Paviours, street masons, concretors, and asphalters	209	154
Council labourers, road sweepers, dustmen	173	172
Drivers of horse-drawn vehicles	144	184
Motor drivers (goods and passengers)	142	100

(4) *Grooms, horsekeepers, carpenters.* Grooms and horsekeepers, who are exposed to various forms of dust arising from horses and fodder, have an almost normal liability to cancer of the lung (106) and no very high incidence of cancer of the larynx (134). Carpenters also show low ratios (lung 73, larynx 82). These instances suggest that exposure to dust *per se*, irrespective of its chemical nature, does not conduce to cancer of the lung.

(5) *Silicosis.* The question must be considered, whether there is any association between silicosis and cancer of the lung. The occupations in which silicosis is prevalent are shown in Tables VI and VII taken from the Annual Reports of the Senior Medical Inspector of Factories (see Bridge).

Of 700 death certificates from England and Wales in 1930 in which death was attributed to pulmonary disease involving fibrosis of the lungs, silicosis was mentioned as a cause of death in 241, and in these the industries were distributed as shown in Table VI (Bridge, 1931).

The occurrence of silicosis in various occupations is shown in Table VII, taken from the Report (for 1934) of the Senior Medical Inspector of Factories which gives data for the fatal cases that came to the knowledge of the Home Office over a number of years (Bridge, 1935).

Some data have been obtained in the present investigation upon the

Table VI. *Silicosis*

Pottery industry	52	Sand blasting	10
Sandstone industry ...	49	Tin mining	10
Quarrymen	13	Lead mining	2
Stonemasons	36	Granite industry	2
Coal mining	39	Mining engineering	2
Grinding industry ...	36	Scouring powders	1
Gold mining ... ... (*ex* South African miners)	23	Slate quarrying	1
		File cutting	1
Refractories industries ...	12	Leather dressing	1

Table VII. *Cases of silicosis in certain occupations*

Industry	Number of deaths	Average age at death	Duration of employment in years		
			Longest	Shortest	Average
Pottery:					
Silicosis	137	57·2	60·0	2·8	38·5
Silicosis with tuberculosis	131	54·1	67·0	5·0	36·9
Sandstone:					
Silicosis	65	56·1	57·0	9·0	37·9
Silicosis with tuberculosis	77	54·0	53·0	15·0	35·2
Grinding of metals:					
Silicosis	20	55·3	56·0	18·0	34·3
Silicosis with tuberculosis	55	52·0	52·0	2·8	30·9
Sandblasting:					
Silicosis	11	43·5	20·0	4·0	11·1
Silicosis with tuberculosis	30	45·4	20·0	2·5	8·9
Manufacture of scouring powders:					
Silicosis	7	36·1	37·0	2·3	10·1
Silicosis with tuberculosis	2	33·5	10·8	2·0	6·4
Miscellaneous:					
Silicosis	21	54·4	45·0	6·0	22·3
Silicosis with tuberculosis	20	50·0	41·0	9·0	26·7

incidence of cancer of the lung in these occupations. No death certificates have been found in which the occupation of the deceased was given as the manufacture of scouring powders, but this work is often carried out on a part-time basis, generally by women, and no figures for the population engaged in it are available. One case of cancer of the lung in a sandblaster has been noted (in 1930) in the period in question; the number of sandblasters is 920. Evidently close attention must be paid to this occupation in the examination of certificates for years subsequent to the latest (1932) considered here. Metal grinders have a high ratio for cancer of the lung (229; Table III). Stonemasons, cutters, and dressers show a slightly increased ratio (149), while stone miners and quarriers, numbering over 28,000 men, have a normal figure for cancer of the lung (105) and a low figure for cancer of the larynx (73); these occupations will of course include many men who are working with non-silicious rocks.[1] Potters' ware makers, casters and finishers have rather high ratios for lung (152) and larynx (184). The low incidence of both forms of cancer upon coal miners was referred to above (p. 246). The general indication of these results is that the

[1] Dible (1934) has described autopsies in three cases of silicosis in stonemasons, in one of whom there was an anaplastic carcinoma of the lung, and in another oat-cell carcinoma of the lung and also a columnar-cell carcinoma of the pelvic colon.

factors which lead to silicosis are not very active in producing cancer of the lung or larynx. No cases of cancer of the lung or larynx in asbestos workers have been found among the certificates dealt with in this paper.[1]

(6) *Alcohol and tobacco.* There is a considerable difference between occupations associated with the supply of alcohol, and of tobacco; the former show a very high incidence upon the larynx, the latter a rather high incidence upon the lung.

Table VIII. *Occupations associated with the supply of alcohol and tobacco*

	Ratio	
	Lung	Larynx
Barmen	104	469
Cellarmen	92	317
Licensed victuallers	128	185
Tobacco manufacturers	196	65
Tobacconists and their assistants	175	142

The occupations of barman and cellarman show by far the highest figures of any in Table IV for cancer of the larynx.

(7) *Coal-gas and tar.* The occupations associated with coal-gas and tar are important on account of the known liability of the workmen to cancer of the skin and of the bladder, but they offer unsatisfactory statistical material because some of the most important occupations employ very few men, and hence produce but few cases of cancer, so that the sampling error is high even over a 12-year period. This difficulty can only be met by omitting some of the smaller classes.[2] Thus, in Table IX there are ten occupations in which there is especial exposure to coal-gas and tar. If from these ten one excludes the five which have produced less than ten deaths from cancer of the lung, one obtains, by this quite arbitrary procedure, the following results:

[1] Lynch and Smith (1935) have described a case occurring in the United States of asbestosis and epidermoid carcinoma of a bronchus in a man who had been a "cotton-mill weaver" for 22 years and then for the last 21 years of his life an asbestos-mill weaver.

Gloyne (1935) records two cases of fairly advanced asbestosis, with squamous carcinoma of the lung, in women workers in England. "One survived nine years after an eight years' exposure to asbestos dust as a spinner; the other lived for fifteen years after two short periods of six months and thirteen months' exposure in the mattress and opening departments of the factory....The malignant lesions of the lung were, in each case, very small and were not recognised during life."

[2] Another factor must be considered in connection with these small classes. A given occupation may involve liability to more than one form of cancer, *e.g.* to cancer of the skin and to cancer of the bladder. It is obvious that a tar distiller, for instance, who dies of cancer of the bladder will not die of cancer of the lung, although his occupation may expose him to abnormal risk of both diseases. Hence to investigate the occupational incidence of cancer thoroughly one should have before one, simultaneously, comparable figures for cancer of all parts of the body which could be affected by an external agent. We have not at present the organisation to supply such complete data, which require a very large amount of computing. Thus we have data for cancer of the lung and larynx for 1921–32, and for cancer of the bladder and prostate for a part of this period only (1921–8). In this connection it is perhaps just worthy of note that the incidence of cancer of the bladder appears to be high in some of the occupations in Table IX in which the figures for cancer of the lung are low, and conversely.

Table IX

	Population	Cancer of bladder (1921–8) Deaths	Ratio	Cancer of lung Deaths	Ratio	Cancer of larynx Deaths	Ratio
Gas stokers and coke-oven chargers	12,818	7	156	37	342	20	186
Gas-works foremen and inspectors	5,443	2	83	10	197	4	75
Gas fitters	15,081	8	205	16	182	8	96
Chimney sweeps	5,900	4	89	11	170	15	192
Gas-works labourers	33,394	21	117	46	161	32	103
	72,636	42		120		79	
Excluded:							
Patent fuel workers	847	2	400	2	433	—	—
Gas-works managers	1,303	2	222	3	244	1	76
Gas producermen	3,195	3	143	4	162	2	88
Gas-works engine and crane drivers	1,854	4	400	1	60	4	233
Tar distillery workers and coke-oven workers	9,697	4	333	2	29	4	60

Thus all the five occupations retained, which employ over 72,000 men and yield 120 cases of cancer of the lung, have a high ratio for this disease (from 161 to 342). The ratios for cancer of the larynx are irregular throughout this class.

(8) Of the sixteen occupations in Table III having ratios for cancer of the lung above 150

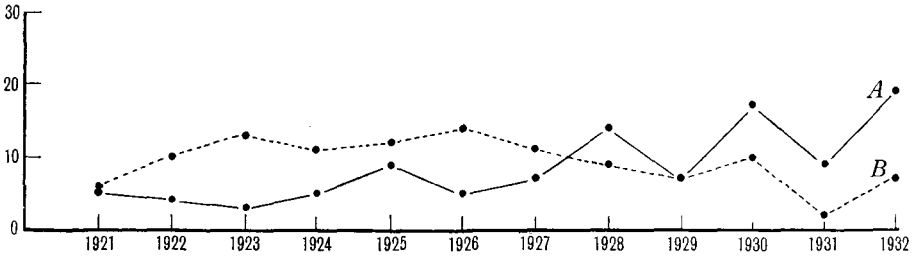
7 involve exposure to coal-tar products.
1 involves exposure to producer gas.
2 involve exposure to road dust.
2 involve exposure to silica.
2 involve exposure to tobacco.

14

The remaining two of these sixteen are French polishers (167) and potters' ware makers, casters and finishers (152).

(9) A group of professional workers (stockbrokers and stockjobbers; clergymen; Roman Catholic priests and monks; ministers of other religious bodies; judges, stipendiary magistrates and barristers; solicitors; physicians, surgeons and registered medical practitioners; dental practitioners) numbering over 105,000 men and showing 104 deaths from cancer of the lung and 112 from cancer of the larynx, give altogether ratios rather below the average (lung 94, larynx 84, Table X and Graph 1). When the individual occupations are examined considerable variations are found. Thus both judges, stipendiary magistrates and barristers, and stockbrokers and stockjobbers, show a distinctly high ratio for cancer of the lung (187 and 173); the numbers of deaths upon which these ratios are based are not very small. Observations over a longer term of years will be needed to show whether this is an instance of a sampling error, or of a special occupational incidence. The figures for Roman Catholic priests and monks are too small to be significant. In regard to the

view that the recent rapid increase in recorded deaths from cancer of the lung is due to the detection of more cases by improved diagnosis, the very moderate ratio (129) for cancer of the lung in medical men is noteworthy, for this is an occupation where the availability of the existing methods for the detection of cancer is presumably at a maximum.



Graph 1. Professional occupations. *A*, cancer of lung; *B*, cancer of larynx.

Table X. *Professional occupations*

		Cancer of lung		Cancer of larynx	
	Population	Deaths	Ratio	Deaths	Ratio
Stockbrokers and stockjobbers	6,893	14	187	15	173
Clergymen (Anglican Church)	23,422	15	53	16	43
Roman Catholic priests and monks	3,604	1	31	2	54
Ministers of other religious bodies	11,769	5	38	9	54
Judges, stipendiary magistrates, and barristers	3,658	7	173	3	57
Solicitors	17,306	19	100	30	128
Physicians, surgeons and registered medical practitioners	27,951	35	129	27	85
Dental practitioners	10,494	8	103	11	148
Total	105,097	104	94	112	84

(10) Cotton strippers, grinders, and card-room jobbers, among whom severe bronchitic and asthmatic affections occur, show only one case of cancer of the lung, and two of cancer of the larynx.

(11) Cotton spinners and piecers have a very low ratio for lung (31) and a rather high ratio for larynx (148). The total calculated population of 38,817 includes ring spinners as well as mule spinners,[1] but the latter occupation certainly makes up a very large proportion of the total for the number of mule spinners aged 20 and over was estimated in 1926 as 41,000 by the Departmental Committee appointed to consider Evidence as to the Occurrence of Epitheliomatous Ulceration among Mule Spinners (1926). In view of the exposure to oils which may be carcinogenic (see p. 264) the low incidence of cancer of the lung is remarkable, but the very high incidence of cancer of the skin, and the increased liability to cancer of the bladder (1) in this occupation, must be taken into account (see footnote, p. 248).

[1] Separate figures for the populations engaged in these two occupations are not available.

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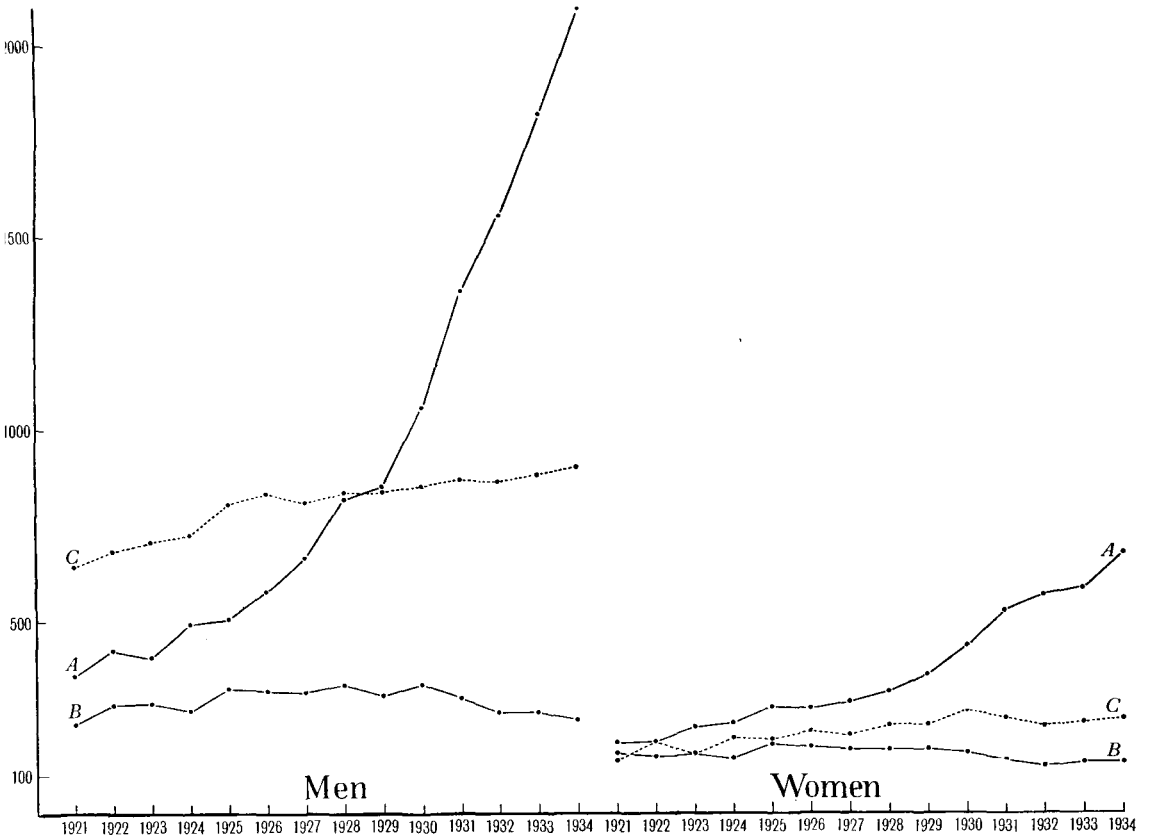
VII. RATE OF INCREASE OF CANCER OF LUNG AND OF LARYNX IN MEN AND IN WOMEN

In Table XII and Graph 2 we are enabled by the kindness of the Registrar-General, to include the total figures for 1933 and 1934, making a 14-year period in all. The individual certificates for the last two of these years have not yet been examined.



Graph 2. Cancer of lung, larynx, and mediastinum in men and in women, 1921–34. *A*, cancer of lung; *B*, cancer of mediastinum; *C*, cancer of larynx.

Cancer of lung

Cancer of the lung has increased from 361 to 2095 cases per annum in men, and from 186 to 680 cases in women. These figures are in the ratio of 1 : 5·8 (men) and 1 : 3·65 (women). The increase became more rapid in 1926 and again in 1930 in men, and about 1929 in women. The annual increase, in men, since 1929 has been at the rate of from 200 to 300 cases per annum. The ratio between deaths from cancer of the lung in men, and in women, is now (*i.e.* in 1932, the latest year for which published figures are available) practically the

same as the corresponding figure for cancer of the oesophagus (Table XI), while in cancer of the mouth region the preponderance of males is still much greater. During the whole period under consideration here (1921–34) the ratio of female to male deaths from cancer of the lung has changed from 1 : 1·94 to 1 : 3·08.

Table XI. *Cancer of lung, oesophagus and mouth region in men and in women*

	Women	Men	Ratio
1932. Cancer of lung	565	1553	1 : 2·75
1932. Cancer of oesophagus	661	1774	1 : 2·68
1932. Cancer of mouth, lip, tongue, tonsil, pharynx	536	3040	1 : 5·67
1921. Cancer of lung	186	361	1 : 1·94
1934. Cancer of lung	680	2095	1 : 3·08

Table XII. *Totals of death certificates, England and Wales*[1]

	Cancer of lung		Cancer of mediastinum		Cancer of larynx	
	Men	Women	Men	Women	Men	Women
1921	361	186	231	157	641	138
1922	423	189	286	146	684	183
1923	405	225	288	157	706	159
1924	493	233	270	141	724	198
1925	508	276	327	180	801	191
1926	578	272	320	172	831	212
1927	666	290	316	166	809	201
1928	814	314	333	165	831	227
1929	849	359	308	169	831	230
1930	1056	433	338	159	852	265
1931	1358	522	300	139	870	247
1932	1553	565	262	123	866	229
1933	1820	582	262	132	882	236
1934	2095	680	244	131	902	243

[1] These figures give the totals of death certificates of *all* age groups, which have not been selected on quite the same basis as that stated above ("Death certificates taken for examination", p. 238) and therefore differ slightly from some other totals given elsewhere in this paper.

Table XIII. *Annual percentage increase in cancer of lung in men and in women*

	Men				Women			
	Cases	Increase	%		Cases	Increase	%	
1921	361		361 = 100		186		186 = 100	
1922	423	62	117		189	3	102	
1923	405	(−18)	112		225	36	121	
1924	493	88	137		233	8	125	
1925	508	15	141		276	43	148	
1926	578	70	160		272	(−4)	146	
1927	666	88	185		290	18	156	
1928	814	148	225	814 = 100	314	24	169	314 = 100
1929	849	35	235	104	359	45	193	114
1930	1056	207	292	130	433	74	233	138
1931	1358	302	376	167	522	89	281	166
1932	1553	195	430	191	565	43	304	180
1933	1820	267	504	224	582	17	313	185
1934	2095	275	580	257	680	98	365	216

Graph 2, at first sight, suggests that the rate of increase in recent years of deaths attributed to cancer of the lung is much greater in men than in women,

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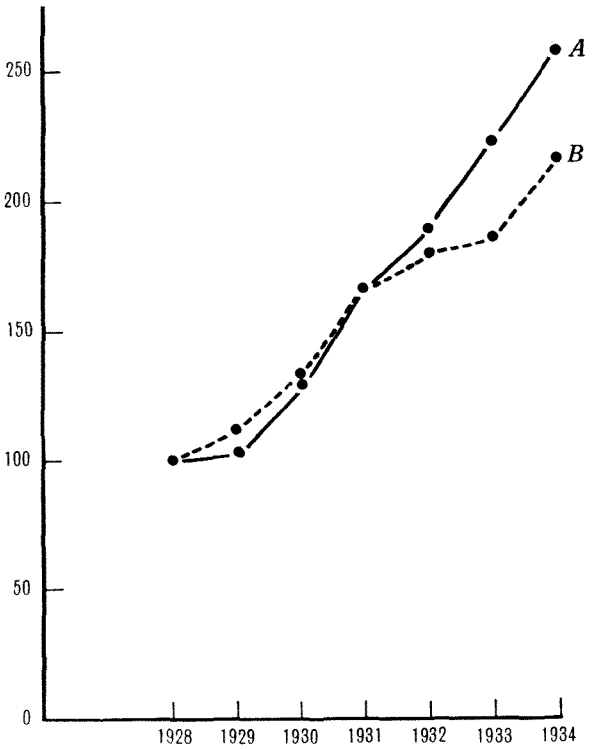
for the curve of deaths of males rises much more steeply than does that of deaths of females. But this apparent great difference between the sexes is due in large part to the fact that, in a graph of this type, a given increase in a larger quantity is much more conspicuous than is the same percentage increase in a smaller quantity. If one reckons the annual numbers of deaths as a percentage of those in any given initial year, the difference between the two sexes is not nearly so conspicuous (cf. Graphs 2 and 3), and this is more especially the case if one takes a short period, say from 1928 onwards, in which recent years the apparent difference in rate of increase in males and females is,



Graph 3. Percentage increase in cancer of lung in men and in women, 1928–34. *A*, men; *B*, women.

in the ordinary form of graph, most evident. Thus, if the number of deaths in 1928 from cancer of the lung in either sex is taken as 100, the number in 1934 corresponds to 257 in men and 216 in women (Graph 3 and Table XIII), a result which one might not anticipate from inspection of Graph 2. The more rapid increase in men than in women of cancer of the lung has been held to be evidence of the reality of the increase in general, because, so it was said, there was no reason why improvement in diagnosis should tell upon the male, more than upon the female, population. But Passey and Holmes (1935) have pointed out that twice as many men as women are entitled to medical benefits

under the National Health Insurance Acts, and hence may have access to better means of diagnosis. In view of this factor it does not seem possible to base any conclusions upon the disparity of the figures for the two sexes in this country at any rate.

Cancer of larynx

Cancer of the larynx has increased from 641 to 902 cases per annum in men, and from 138 to 243 cases in women. These figures are in the ratio of 1 : 1·4 (men) and of 1 : 1·75 (women). But in women there has been no uniform increase since 1928. Hence if the adoption of smoking has had any effect upon their liability to the disease, this factor has reached equilibrium.

VIII. Cancer of mediastinum

The cases of cancer of the mediastinum show (Graph 2), most distinctly in men, a plateau between 1925 and 1931, from which there has been a descent in more recent years, which is due probably to the transference of cases to the category of cancer of the lung by gradual improvement in radiographic diagnosis. (The category of cancer of the mediastinum in the tables of the General Register Office comprises all cases where a mediastinal tumour is described by any term signifying malignancy either in the original certificate, or in answer to an enquiry for a more exact statement when the case had been described simply as one of mediastinal tumour, new growth or neoplasm. Many of these tumours are lympho-sarcomas, but probably a certain number are carcinomas of the hilum of the lung, for it is not always possible to distinguish a lympho-sarcoma of the mediastinum from a carcinoma of the hilum even at autopsy, until microscopic sections have been prepared. If these tumours cannot always be discriminated at an autopsy they will certainly be confused without one, and hence a certain number of true carcinomas of the lung will be lost in this classification. But this error is preferable to the inclusion, in one class, of tumours of the mediastinum and of the lung, because the true tumours of the mediastinum must differ from those of the respiratory tract in their relation to those external factors[1] which are of especial interest in relation to cancer. Another possible error arises from the fact that mediastinal metastases from a small primary cancer of the lung may be so large as to simulate the signs of a primary mediastinal neoplasm.)

IX. Possible factors which might cause an increase in the deaths attributed to cancer of the lung

The increase in recent years in the number of deaths attributed to cancer of the lung may be due to one, or more than one, of the following factors:

(1) An increase in the actual number of cases of the disease.

(2) Improvement in diagnosis, whereby a larger proportion of the actual

[1] All of the eighteen cases of tumour of the lung in Schneeberg miners which have yielded satisfactory histological material have been carcinomata (twelve squamous-celled with seven showing keratinisation, six polymorphous) (Rostoski, Saupe and Schmorl, 1926).

number of cases is detected in life; and an increase in the number of autopsies performed (see above, p. 239).

(3) A tendency to identify as cancer of the lung cases which are really of a different nature; that is, a fashion in diagnosis.

These three possibilities may now be considered in detail.

(1) *An actual increase*

It is obviously difficult to obtain any *direct* evidence of this factor; one is driven to seek for indirect evidence by means of enquiry, how far the second and third factors can be excluded.[1]

The actual number of cases of any form of cancer must depend upon the size of the population of the country, and upon the distribution of age and sex within this population. But the increase in recorded cases of cancer of the lung is too great to be accounted for by any such influences (see below under "Standardized mortality rates").

The dissemination of tar from roads has been thought to be a factor which must produce an increase in cancer of the lung. This matter is discussed below under "Tarring of Roads".

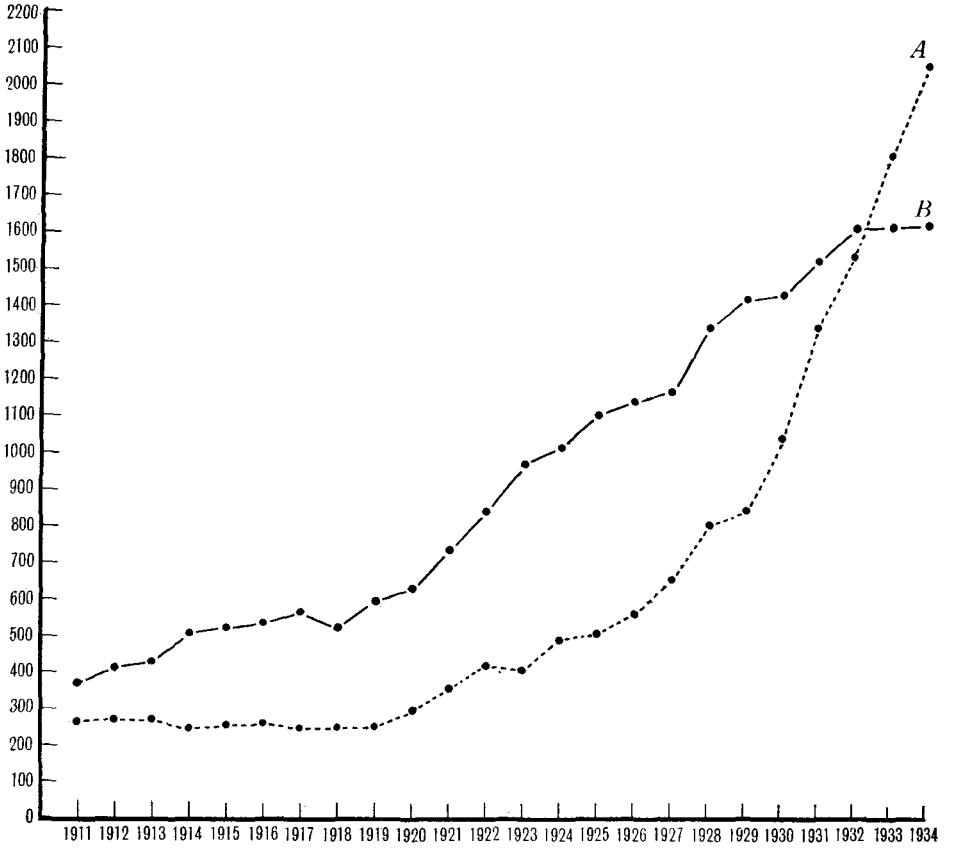
(2) *Improvement in diagnosis*

The methods of examination of the lungs, and the provision of apparatus for such purposes, have undergone very great development in the last fifteen years, and it would be remarkable if these changes had not increased the number of cases of cancer of the lung detected. Hence there can be no doubt that this accounts in part for the apparent increase in the prevalence of cancer of the lung, but the question remains, whether a real increase is occurring also. If improvement in diagnosis is the whole explanation of the sharply rising curve in Graph 2 then over 1000 deaths from cancer of the lung in men in 1930 must have been ascribed to other diseases (see the figures for 1930 (1056 deaths) and for 1934 (2095 deaths) in Table XII). Obviously this factor will cease to act when the methods of diagnosis, and their availability to the whole population, cease to improve; hence it will be of great interest to see the changes in the prevalence of cancer of the lung in, say, the next 10 years.

A comparison of the prostate with the lung in this respect is of interest. Cancer of the prostate has shown a rate of apparent increase (Graph 4) which

[1] A possible source of evidence as to the reality of the increase in cancer of the lung has been pointed out to us by Dr C. Worster-Drought. Patients bearing cerebral metastases from cancer of the lung, in whom the primary tumour is not detected during life, may be sent to neurological hospitals, and some physicians who see such cases find that these have become much more common of recent years. Obviously neither improvement, nor fashion, in diagnosis of cancer of the lung comes into play here. Prof. J. M. Woodburn Morison tells us that the more rapid increase in recorded cases of cancer of the lung in males which began in 1925–6 (Graph 2) cannot be attributed to the introduction at that time of any technical improvement in radiological diagnosis. But an improvement in the availability of the existing methods to various classes of the population is of course another possibility, upon which we have no information.

is very similar to that of cancer of the lung in males. The graph shows the recorded deaths from these two forms of cancer in England and Wales for the 24 years 1911–34. The number of cases of cancer of the lung remains at a very constant level of about 250 during the period 1911–19, and then shows a rise of increasing steepness to more than eight times that figure, or 2095, in 1934. The deaths from cancer of the prostate show a more uniform increase, though here again there is a tendency for a more rapid rise to set in during 1918–20; the latest figures available, namely those for 1932–3–4 (Table XIV) indicate that the increase is coming to an end.



Graph 4. Cancer of lung in males, and cancer of prostate, 1911–34.
A, cancer of lung; *B*, cancer of prostate.

Table XIV. *Cancer of prostate*

	Deaths	Standardised mortality rate
1930	1434	54·9
1931	1532	56·4
1932	1623	58·5
1933	1629	57·4
1934	1639	—

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Recent investigations[1] have shown that areas of tissue regarded as malignant can be found at autopsy in a high proportion of prostates, if a sufficiently minute search be made. There is thus in the case of the prostate a reservoir of malignancy which is drawn upon in proportion to the thoroughness of the examination, and it is probable that the same is true of the lung.

Passey and Holmes (1935) in an elaborate study for the years 1894–1928 of the numbers of intrathoracic neoplasms in relation to admissions to sixteen hospitals, found an increase in such tumours in five hospitals only of the sixteen, and these authors conclude that the reader "will find it difficult to make out a serious case for any appreciable increase in the incidence of intrathoracic neoplasia in the period 1894–1928...". This may be so, but it is difficult to see why the recent great increase in certification of deaths from cancer of the lung (Graph 2) did not take effect upon more of the hospitals dealt with by Passey and Holmes, for one cannot suppose that the diagnoses in these institutions in, say, 1919, left no room for improvement.

(3) *Fashion in diagnosis*

The suggestion has been made that there is now a tendency to identify as cancer of the lung cases which are really of a different nature. If this factor is to account for the present form of the curve (Graph 2) one must suppose that every year medical men diagnose two or three hundred *more* cases wrongly; it will be interesting to see for how many years this course of action persists so as to maintain the curve in its present shape. Also, there must be a sufficient supply of patients who have intrathoracic conditions which are not cancer of the lung but are sufficiently severe to cause death. It seems very unlikely that this third factor can have any large influence upon the figures in question.

[1] R. A. Moore (1935) describes small areas of carcinoma found at autopsy, when several blocks from each prostate were cut, in 20·2 per cent. of all males over 40, below which age none was found. His results are shown in the following table:

Age group	Prostates examined		Prostates showing carcinoma	
21–30	24		0	
31–40	28		0	
41–50	252	23	51	4 (17 %)
51–60		65		9 (14 %)
61–70		77		18 (23 %)
71–80		63		13 (21 %)
81–90		24		7 (29 %)

Cf. the confirmatory work of Rich (1935) who found areas of carcinoma in forty-one, or 14 per cent., of 292 consecutive autopsies on males of 50 or over when one block only from each prostate was cut; in fourteen only of the forty-one cases had cancer been recognised clinically, and in most of those not detected clinically the cancer was not perceptible by the naked eye.

The number of deaths of males aged 41 and over in England and Wales in 1934 was 196,131. If one were to apply Moore's figure in this case, the result obtained would be that 20 per cent. of these men, or over 39,000, bore cancer of the prostate at the time of death. This figure one may compare with the 24-fold smaller number, namely 1639 (Graph 4 and Table XIV), in which this form of cancer was returned as the cause of death. Of course one cannot assume that the findings at the autopsies in question apply to all males who die aged 41 and over.

X. Occupational incidence of the increase of cancer of the lung

If there is a real increase in cancer of the lung, and if this is due to any external factor, one would expect to find differences in the rate of increase in classes of persons exposed to different environments. The annual numbers of deaths from cancer of the lung, and of the larynx, in each one of the occupations studied in detail in this paper can be seen in Table XV. The increase in the total of recorded cases has been so great (Graph 2) that, if this increase were due to a contribution from any of the smaller occupations, the incidence upon these would have to be very high indeed.

Table XV. *Twelve years' registered deaths from cancer of lung and larynx in fifty-six occupations*

		1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	Total
Labourers, patent fuel works:	Lung	—	—	—	—	—	—	2	—	—	—	—	—	2
	Larynx	—	—	—	—	—	—	—	—	—	—	—	—	0
Gas stokers and coke-oven chargers:	Lung	2	1	—	2	2	4	4	2	3	1	8	8	37
	Larynx	3	1	—	2	2	2	—	1	1	3	1	4	20
Gas-works managers:	Lung	—	—	—	1	1	—	—	—	—	1	—	—	3
	Larynx	—	—	—	—	—	1	—	—	—	—	—	—	1
Metal grinders:	Lung	—	1	2	2	1	2	—	—	2	2	2	5	19
	Larynx	—	2	1	1	1	—	1	1	1	—	1	1	10
Paviours, street masons, concretors, asphalters:	Lung	—	1	—	3	—	1	—	1	1	1	1	3	12
	Larynx	—	2	—	—	1	1	1	1	1	1	—	1	9
Sandblasters:	Lung	—	—	—	—	—	—	—	—	—	1	—	—	1
	Larynx	—	—	—	—	—	—	—	—	—	—	—	—	0
Gas-works foremen and inspectors:	Lung	—	2	1	—	1	—	—	—	1	1	3	1	10
	Larynx	—	—	—	—	—	1	—	2	—	—	—	1	4
Tobacco manufacturers:	Lung	—	1	2	2	—	—	—	—	1	1	2	—	9
	Larynx	—	—	—	—	—	—	—	1	—	—	1	1	3
Gas fitters:	Lung	1	2	1	—	3	2	—	—	2	—	3	2	16
	Larynx	1	—	3	1	—	1	—	1	—	—	1	—	8
Tobacconists and their assistants:	Lung	—	1	1	1	2	3	1	2	2	—	2	6	21
	Larynx	3	1	1	—	3	1	2	2	1	2	—	3	19
Mainly council labourers, road sweepers and dustmen*:	Lung	3	2	3	3	5	5	3	5	7	9	13	10	68
	Larynx	5	3	7	4	3	9	8	8	9	5	10	7	78
Chimney sweeps:	Lung	—	—	—	—	—	1	—	2	—	1	3	4	11
	Larynx	—	—	—	2	1	—	2	1	2	3	3	1	15
French polishers:	Lung	2	—	2	2	—	—	2	1	—	3	2	5	19
	Larynx	1	2	—	1	—	—	1	1	3	2	3	1	15
Gas producermen:	Lung	—	—	—	—	—	—	—	—	—	1	—	3	4
	Larynx	—	—	1	—	—	—	1	—	—	—	—	—	2
Gas-works labourers:	Lung	2	1	5	1	2	2	2	4	3	5	6	13	46
	Larynx	3	1	2	2	3	2	1	4	4	2	3	5	32
Potters; ware makers, casters and finishers:	Lung	—	—	—	2	1	1	—	—	2	1	1	1	9
	Larynx	4	—	—	—	4	—	1	—	—	2	—	—	11
Stonemasons, cutters and dressers:	Lung	1	4	2	5	6	4	3	8	4	6	6	4	53
	Larynx	6	2	4	2	5	5	5	2	3	7	5	5	51
Tanners, leather dressers, curriers, skilled workers:	Lung	1	—	1	1	—	—	2	1	4	3	5	3	21
	Larynx	—	—	1	1	—	2	1	2	—	—	2	2	11
Drivers of horse-drawn vehicles:	Lung	6	15	11	7	14	13	14	13	14	16	24	30	177
	Larynx	9	24	20	26	18	18	25	25	22	13	19	23	242
Motor drivers, goods and passengers:	Lung	3	5	4	6	6	10	8	15	19	14	21	25	136
	Larynx	1	2	8	6	6	5	4	7	10	4	5	7	65
Cabinet makers:	Lung	3	2	2	1	1	5	4	2	2	3	1	8	34
	Larynx	—	4	10	4	4	3	4	5	5	2	2	3	46
Blast furnace engine men:	Lung	—	—	—	—	—	—	—	—	—	1	—	—	1
	Larynx	—	—	—	—	—	—	—	—	—	—	—	—	0
Licensed victuallers:	Lung	4	4	4	6	5	7	9	5	13	16	18	16	107
	Larynx	13	11	9	12	23	19	10	20	10	21	13	12	173

* 1931 Census only.

https://doi.org/10.1017/S0022172400043618 Published online by Cambridge University Press

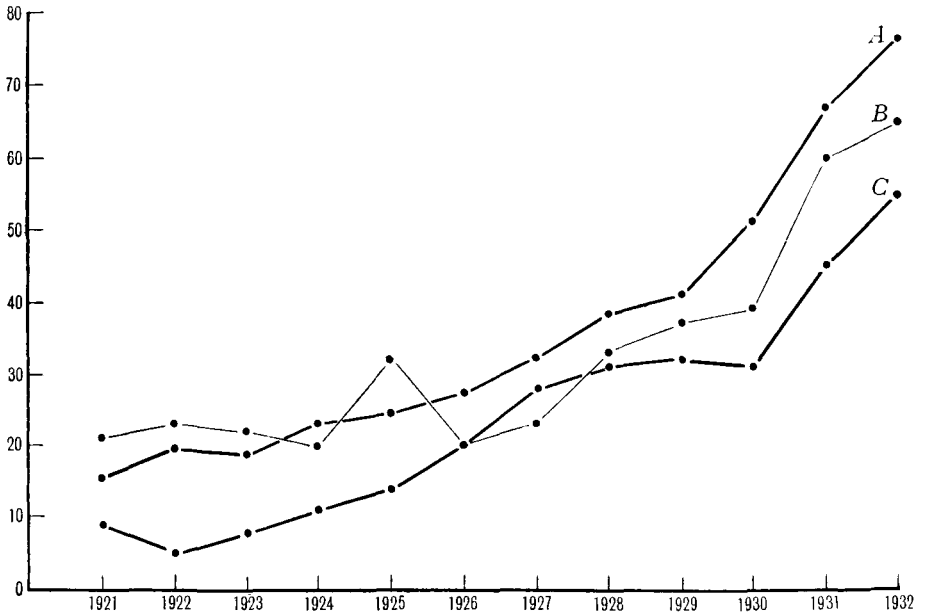
Table XV (*continued*)

		1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	Total
Painters:	Lung	5	4	9	9	6	9	12	19	21	19	24	39	176
	Larynx	15	13	14	16	16	17	19	19	19	16	14	17	195
Grooms, horsekeepers:	Lung	—	2	1	2	1	3	1	4	5	1	4	6	30
	Larynx	4	3	7	4	2	6	3	2	3	2	5	2	43
Stone miners and quarriers:	Lung	1	2	—	2	—	—	3	2	1	2	4	5	22
	Larynx	—	2	—	1	1	2	1	4	2	1	1	1	16
Barmen:	Lung	—	—	—	—	—	—	—	1	1	3	3	2	10
	Larynx	2	1	1	6	3	3	2	5	6	4	2	4	39
Plumbers:	Lung	1	2	2	5	2	2	3	3	2	5	3	3	33
	Larynx	2	3	3	2	4	3	2	2	3	4	6	2	36
Printers:	Lung	4	3	1	—	4	3	2	4	7	9	11	13	61
	Larynx	4	4	6	2	6	11	4	2	12	5	10	5	71
Pottery, etc.: kiln and ovenmen, kiln setters and placers:	Lung	—	—	—	—	—	—	—	1	1	—	1	5	8
	Larynx	—	—	1	—	1	2	—	1	—	1	3	—	9
Potters' mill workers; slip makers and arkmen:	Lung	—	—	—	—	—	—	—	—	—	—	—	1	1
	Larynx	—	—	—	—	—	—	—	—	—	—	—	—	0
Professional men:	Lung	5	4	3	5	9	5	7	14	7	17	9	19	104
	Larynx	6	10	13	11	12	14	11	9	7	10	2	7	112
Cellarmen:	Lung	—	—	—	—	1	—	—	1	—	—	1	1	4
	Larynx	1	1	—	—	4	1	3	—	—	4	—	—	14
Bakers and pastry cooks:	Lung	1	1	2	2	2	5	4	4	3	4	4	5	37
	Larynx	6	4	3	8	2	4	3	2	3	6	7	1	49
Blast furnacemen and labourers:	Lung	2	—	—	—	—	1	—	1	1	—	1	—	6
	Larynx	—	1	—	—	—	—	—	1	—	—	—	1	3
Hairdressers:	Lung	—	—	—	1	3	1	1	—	1	6	1	6	20
	Larynx	1	2	3	2	2	1	1	1	2	3	3	7	28
Lithographic and process engravers:	Lung	1	—	—	—	—	—	—	—	—	1	—	1	3
	Larynx	—	—	—	—	—	—	—	1	1	—	—	1	3
Locomotive engine drivers, firemen and cleaners:	Lung	1	1	1	4	4	3	1	4	5	5	5	7	41
	Larynx	1	2	2	2	4	2	3	2	3	4	1	4	30
Carpenters:	Lung	3	6	3	7	5	9	5	13	17	16	19	20	123
	Larynx	13	9	12	12	19	11	9	7	12	24	16	15	159
Stationary engine and crane drivers:	Lung	4	3	1	5	5	2	—	3	4	5	4	6	42
	Larynx	5	6	3	1	2	6	4	2	6	5	6	3	49
Coal miners, workers above ground:	Lung	2	2	1	1	5	3	—	5	2	6	8	11	46
	Larynx	3	2	1	3	6	2	2	4	4	6	1	5	39
Coal miners, hewers:	Lung	6	2	6	5	6	14	18	19	19	17	26	36	174
	Larynx	10	10	9	19	11	11	9	13	14	19	13	12	150
Gas-works engine and crane drivers:	Lung	—	—	—	—	1	—	—	—	—	—	—	—	1
	Larynx	—	1	—	—	—	—	—	—	2	—	—	1	4
Gardeners:	Lung	3	8	9	4	8	6	11	8	10	15	18	18	118
	Larynx	16	13	14	14	13	19	22	18	14	18	16	17	194
Farmers:	Lung	9	5	9	8	16	8	8	13	16	17	20	24	153
	Larynx	11	10	11	10	6	18	10	13	15	14	12	13	143
Coal miners, making roads:	Lung	1	—	—	2	—	1	5	3	4	6	3	4	29
	Larynx	—	5	3	3	1	1	2	4	—	—	3	5	27
Brick and plain tile makers:	Lung	1	—	—	—	—	—	—	—	—	—	2	—	3
	Larynx	—	—	—	—	—	4	1	—	—	—	—	2	7
Cotton weavers	Lung	—	—	1	2	—	1	—	2	1	2	1	3	13
	Larynx	1	1	—	1	3	3	2	1	1	—	4	5	22
Coal miners, other workers below ground:	Lung	—	1	—	3	2	2	5	2	4	—	7	2	28
	Larynx	3	4	2	—	2	3	2	4	3	3	3	1	30
Coal miners, conveying material to the shaft:	Lung	—	—	1	—	1	—	—	2	3	2	1	2	12
	Larynx	—	—	—	—	—	1	1	—	1	3	3	2	11
Agricultural labourers including shepherds:	Lung	8	10	4	7	8	5	4	12	11	7	21	22	119
	Larynx	8	13	16	15	9	21	14	16	9	16	17	20	174
Cotton spinners and piecers:	Lung	—	—	—	—	—	4	1	1	—	—	—	1	7
	Larynx	1	2	4	3	2	4	1	3	3	3	3	2	31
Tar distillery workers and coke-oven workers:	Lung	—	—	—	—	1	—	—	—	—	—	—	1	2
	Larynx	—	1	—	—	—	—	—	—	—	1	—	2	4
Farm bailiffs and foremen:	Lung	1	—	—	1	—	1	—	—	—	—	1	1	5
	Larynx	—	1	1	—	—	1	1	—	—	2	1	2	9
Brick kiln and ovenmen:	Lung	—	—	—	—	—	—	—	1	—	—	—	—	1
	Larynx	—	—	—	—	—	1	—	1	—	—	1	—	3
Cotton strippers and grinders and card-room jobbers:	Lung	—	—	—	—	—	—	—	—	—	1	—	—	1
	Larynx	—	—	—	—	—	—	—	—	—	—	2	—	2

For example, if one takes the numbers of deaths from cancer of the lung (*a*) in those occupations where there is especial exposure to road dust (Table V), (*b*) in the fourteen other occupations showing a ratio above 150 for cancer of the lung (Table III, and p. 249), and divides them between the first half (1921–6) and the second half (1927–32) of the whole period, and compares these figures with those given by the whole male population, it becomes quite clear that even these occupations do not account for any large fraction of the whole increase of 3528 cases (Table XVI).

Table XVI. *Increase of cancer of lung in certain occupations*

		Deaths from cancer of lung		
		1921–6	1927–32	Difference
See Table V	Paviours, street masons, concretors, asphalters	5	7	
	Council labourers, road sweepers, dustmen	21	47	
	Drivers of horse-drawn vehicles	66	111	
	Motor drivers	34	102	
		126	267	141
See Table III	14 other occupations with ratios above 150	71	136	65
See Table XII: General population, males		2768	6296	3528



Graph 5. Cancer of lung in coal miners, agricultural workers, and the general population, 1921–32. *A*, general population ÷20; *B*, agricultural workers; *C*, coal miners.

In Graph 5 are shown the numbers of cases of cancer of the lung in the general population, and in the agricultural and coal-mining industries. The three curves are similar in general character, but the rate of increase is rather

less in the agricultural workers, and considerably greater in the coal miners, than it is in the general population. These differences are shown in Table XVII.

Table XVII. *Cancer of lung. Males*

	General population		Agriculture		Coal-mining	
	Deaths	Ratio	Deaths	Ratio	Deaths	Ratio
1921	361	1	21	1	9	1
1932	1553	4·3	65	3·095	55	6·1

The rather smaller increase in cancer of the lung in the agricultural workers, in comparison with the whole population, does not provide any certain ground for inferences about the action of town dust or smoke, because many open-air workers in the more remote districts may have less access than have town dwellers to modern methods of diagnosis.

The investigation described in the present paper has not brought to light evidence that the increase in total cases of cancer of the lung comes largely from any special classes of the population.

XI. STANDARDISED MORTALITY RATES

The figures given in Table XII for the recorded deaths attributed to cancer of the lung during the period considered here, namely 1921–32, require to be compared with the standardised mortality rates, in which the influence of changes in the population, in the age distribution, and in the proportion of the sexes, is eliminated (Table XVIII; the figures are taken from *The Registrar-General's Statistical Review of England and Wales for the year* 1927, Text, p. 65, and from the corresponding *Report* for 1933, Text, p. 77). The rates for cancer of all sites, and of the oesophagus, pancreas, bladder and prostate are included for the sake of comparison with those for cancer of the lung, mediastinum, and larynx.

The table shows that there have been very large increases in the deaths assigned to cancer of the pancreas, prostate, and lung. If one compares the numbers of deaths (Table XII) and standardised mortality rates (Table XVIII) for cancer of the lung over the longest period available (1926–33) one obtains the following results (Table XIX).

The small difference between the ratios shows that the recent increase in deaths attributed to cancer of the lung cannot be due to any large extent to changes in the amount, age, or sex distribution of the population.

XII. TARRING OF ROADS

Many writers have suggested that the increase in cases of cancer of the lung is due wholly or in part to the tarring of roads. Several comments may be made upon this view.

(1) This explanation assumes:

(*a*) that the increase is, to some extent at any rate, a real one: and

(*b*) that tar inhaled can produce cancer of the lung.

Table XVIII. *Standardised cancer mortality rates per million population*

M. = male; F. = female.

	All sites		Oesophagus		Pancreas		Bladder		Prostate		Mediastinum		Lung		Larynx	
	M.	F.	M.	F.	M.	F.	M.	F.	M.		M.	F.	M.	F.	M.	F.
1901–10	784	942	51·2	14·6	14·5	11·8	?	?	11·8	—	8·1	4·5	10·2	7·0	?	?
1911–20	897	959	60·6	16·5	16·7	13·1	28·2	9·7	26·5	—	9·2	4·6	12·7	7·0	23·9	6·0
1921–30	1004	986	64·2	18·1	26·3	19·5	30·5	11·4	47·7	—	12·6	5·8	25·2	9·6	31·3	7·1
1926	1011	995	65·4	17·8	26·0	21·2	30·0	11·1	47·9	—	13·3	6·0	23·3	9·2	33·5	7·3
1927	1018	984	60·7	18·0	30·3	20·4	30·5	11·6	47·8	—	12·9	6·0	26·8	9·7	31·7	6·9
1928	1032	1000	64·3	18·7	28·8	21·0	32·0	11·9	53·8	—	13·3	5·4	32·0	10·4	31·8	7·6
1929	1031	999	62·3	18·3	30·3	20·0	32·3	12·3	56·4	—	12·1	5·6	33·4	11·9	31·4	7·6
1930	1031	987	61·8	18·6	29·4	23·8	31·8	11·5	54·9	—	13·1	5·3	40·2	13·9	31·6	8·5
1931	1034	974	62·8	18·7	28·8	21·6	34·2	11·0	56·4	—	11·4	4·6	51·2	16·3	31·7	7·9
1932	1052	966	62·5	19·5	32·0	23·1	32·0	11·2	58·5	—	9·8	4·0	57·0	17·2	30·7	7·2
1933	1035	973	57·8	18·3	32·4	24·7	32·5	12·0	57·4	—	9·8	4·1	66·8	17·6	30·8	7·1

The standardised mortality rates for single years before 1926, or after 1933, are not available.

Table XIX. *Standardised mortality rates for cancer of lung*

	Males			Females		
	1926	1933	Ratio	1926	1933	Ratio
Deaths	578	1820	1 : 3·15	272	582	1 : 2·14
Standardised mortality rate	23·3	66·8	1 : 2·87	9·2	17·6	1 : 1·91

The experimental evidence so far available upon this second assumption is very scanty. Kimura in a paper (1923) entitled "Artificial production of a cancer in the lungs following the intrabronchial insufflation of coal-tar", makes the following statement:

"By the intrabronchial insufflation is meant to force a small amount of crude coal-tar into the bronchus through the tracheotomy wound of the animals previously anaesthetized completely. Three rabbits and ten guinea-pigs were used for this series of experiments. Among them, 1 rabbit and 3 guinea-pigs survived. After the treatment the former was killed on the 80th day and the latter on the 140th day; there resulted a small adenomatous area in the lung of the rabbit and a multiple adenocarcinoma in one of the guinea-pigs, which are described in this paper."

He proceeds to describe:

(*a*) Two epithelial tumours, with ossification, in the lung of the guinea-pig. No illustrations of these tumours are given.

(*b*) An encapsulated glandular structure, consisting of twisted tubules, in the lung of the rabbit; of this tumour there is a quite worthless microphotograph. In Schabad's experiment (1932) nothing of the nature of a tumour was produced by the intratracheal injection of tar in 31 guinea pigs.

Argyll Campbell (1934) produced cancer of the skin, and a ten-fold increase in the incidence of primary adenoma of the lung, in mice by exposure to dust from tarred roads; he concludes that "the bearing of this research upon the debated increase in tumours of the human lung cannot be assessed at present". The interpretation of such experiments, and still more the drawing of any inferences from them which shall apply to man, is rendered difficult by the facts that in mice lung tumours (1) occur in mice which have not been exposed to road dust (*e.g.* in seven out of ninety control mice in Argyll Campbell's experiment); (2) are largely controlled by genetic factors (Andervont, 1935); and (3) can be produced by simple application of tar to the skin (Murphy and Sturm, 1925) or in some strains by injection sub cutem of carcinogenic hydrocarbons (Andervont, 1935; Schabad, 1935) by which last method inhalation is excluded altogether.

(2) In spite of the rather high incidence of lung cancer in those occupations where there is exposure to road dust (see above, p. 246), it seems wholly unreasonable to attribute the recent increase of this disease among the general population to the tarring of roads. For scores of years before this increase began coal tar was being discharged into the atmosphere in the form of soot by the domestic fire in quantities vastly greater than any which could now be derived from the roads.[1] Tarring of roads must undoubtedly increase the

[1] Soot from the chimney of a dwelling-house may contain 40 per cent. of tar and the dust deposited from the air in a district such as that of Newcastle-on-Tyne may yield 2·5 per cent. of tar (Cohen and Ruston, 1925).

amount of dust derived from tar in the air,[1] but this increase appears negligible in comparison with the amount of soot present already. One sees clouds of smoke drifting over any large town, but one does not see any similar clouds of tar-laden vapour arising continually from tarred roads.

(3) The contamination of the air with soot has probably been decreasing, owing to the greater use of gas and electricity, before and during the period when the recorded cases of cancer of the lung have been increasing rapidly.

(4) Moreover, such evidence as is available suggests that coal tar in the atmosphere, whether derived from roads, domestic chimneys, or any other source, does not readily give rise to cancer of the lung. Chimney sweeps, who of all persons are most exposed to soot,[2] have not a very high ratio for lung cancer (170, Table III), and the other occupations where there is special exposure to the products of the gas-works (gas stokers, gas works foremen and inspectors, gas fitters, Table IX) show an incidence of lung cancer which is from two to four times that prevailing in the general population. This increased liability, though very undesirable, cannot be regarded as a very high industrial risk. It does not even approach, for instance, the increase of risk of fatal cancer of the scrotum which is incurred in the occupations of chimney sweep or mule-spinner.[3]

(5) Cancer of the lung can undoubtedly be produced by an external agent, for the Schneeberg miners show an extremely high incidence. (Out of 154 miners twenty-one died in $3\frac{1}{4}$ years, and cancer of the lung was found in every one of thirteen of these submitted to autopsy, while of the eight not examined post mortem two had given in life strong evidence of the presence of this disease (Rostoski, Saupe and Schmorl, 1926).) These remarkable data make all the more distinct the indication that the potency of coal tar products, though seen clearly in occupations where there is abundant exposure to these, is nevertheless of a low order. Corroborative evidence of this low potency is afforded by the case of the mule spinners who show an especially small liability to cancer of the lung although they inhale air sprayed with an oil which produces cancer of the skin.[4]

[1] The amount of tar in the air over a tarred road in Germany during the passage of vehicles has been measured by Lehmann (1930) and is stated by him to be of the order of 0·33 mg. tar in a cubic metre of air. The dust from tarred roads used by Argyll Campbell (1934) in his experiments (see p. 263) contained from 1·6 to 2·8 per cent. of tar.

[2] That soot actually is carcinogenic (to the skin of man) has been almost certain for a very long time from the facts of chimney-sweep's cancer, but the conclusive experimental proof (on the skin of the mouse) was given by Passey (1922).

[3] England and Wales. Mean Annual Death Rate per Million from Cancer of the Scrotum: All males 4·1; Chimney-sweeps 534·3; Cotton-spinning Processes 134·0. See *Report* (1926) of Departmental Committee.

[4] The following passage from the *Report of the Departmental Committee appointed to consider Evidence as to the Occurrence of Epitheliomatous Ulceration among Mule Spinners* (1926) is of great interest in this connection: "Dr Middleton, H.M. Medical Inspector of Factories, has made some interesting observations for us with Owen's Dust Counter in certain mule rooms, and, as a check, similar observations in card rooms and in a ring spinning room. Droplets of oil were found

(6) Two phenomena which might be discussed in relation to the tarring of roads and cancer of the lung are (*a*) the parallel increase in lung cancer in country dwellers and town dwellers (Graph 5) and (*b*) the greater increase in lung cancer in men than in women. But one can always argue that tarred roads do, or do not, now penetrate to all parts of the country, or that women, are, or are not, exposed as much as men to road dust, so no useful purpose would be served by any such discussion.

(7) The similarity has been noticed between the curves showing (*a*) the recent increase in cases of cancer of the lung (Graph 2) and (*b*) the onset of mule-spinner's cancer (of the skin) after 20–25 years' employment in cotton mule spinning (Henry, 1928), and the suggestion might be made that the sudden increase in cases of cancer of the lung was traceable to the introduction of tarring of roads about 20 years earlier. But, even if one suppose that road dust is active in producing cancer of the lung, it is wholly improbable that the exposure of the general population to this dust is comparable to the intensive exposure to oil which occurs in the mule room (see footnote 4, p. 264).

XIII. SUMMARY

The death certificates for cancer of the lung and of the larynx in males from England and Wales for the years 1921–32 inclusive, numbering 18,280, have been investigated.

Sources of error in statistical work on death certificates are discussed.

Latterly autopsies have been made upon about 28 per cent. of cases of cancer of the lung, and 9 per cent. of cases of cancer of the larynx. The increase in the recorded cases of lung cancer is not nearly accounted for by the increase of data obtained by autopsy.

The agricultural and coal-mining industries show a low incidence of cancer of the lung and of the larynx.

The factors which lead to silicosis appear not to be very active in producing cancer of the lung or larynx, but in metal grinders the incidence of cancer of the lung is $2\frac{1}{4}$ times that in the general population. A group of open-air occupations, where there is exposure to the dust of roads, have rather high

to be present in the atmosphere of all, but were present to a greater extent in mule spinning rooms than in the other rooms.

"His counts show a much higher number of droplets in the case of samples taken near to recently oiled spindles than in samples taken some time after oiling. Thus in one case 38 droplets in one cubic centimetre of air were found in a sample taken near recently-oiled spindles, while the number of droplets was only four, and so almost negligible, in a second sample, taken at the same place two hours after oiling. This points to the conclusion that the oil in suspension in the air comes from the spindles, and it is, we are satisfied, from this source that the greatest quantity of oil gets not only on to the clothing of the worker but also on to the carriage of the mule and thence on to the floor itself."

The low incidence of cancer of the lung in mule spinners requires to be considered in connection with the high incidence among them of cancer of the scrotum and other parts of the skin (see footnote, p. 248).

ratios for cancer of the lung and of the larynx with the exception that motor drivers have a normal liability to cancer of the larynx. On the whole, no occupation involving exposure to any kind of dust has been found in which there is any very high incidence of cancer of the lung or larynx. Cases of cancer of the lung in asbestos workers are described in recent literature, but none has been found among the certificates considered here (up to 1932).

Workers exposed to coal gas and tar, and those engaged in the preparation and sale of tobacco, tend to show an increased prevalence of cancer of the lung.

Occupations concerned with the supply of alcohol have a high incidence of cancer of the larynx.

To investigate the occupational incidence of cancer thoroughly one should have before one, simultaneously, comparable figures for cancer of all parts of the body which could be effected by an external agent.

With regard to the view, that the recent rapid increase in recorded deaths from cancer of the lung is due to the detection of more cases by improved diagnosis, the very moderate ratio (129) for cancer of the lung in medical men is noteworthy, for this is an occupation where the availability of the existing methods for the detection of cancer is presumably at a maximum.

Data are given of the prevalence of cancer of the lung and larynx in men and in women, and of the rate of increase in the two sexes in recent years. The greater incidence of cancer of the lung upon men than upon women is discussed. The recent rate of increase of cancer of the lung in men is found to be not much greater than that in women, when these increases are reckoned in percentages.

The increase in recorded cases of cancer of the lung may be due to (1) an actual increase; (2) improvement in diagnosis; (3) fashion in diagnosis; or to any combination of these factors. A comparison is made between the increase of cancer of the lung, and of cancer of the prostate; the number of deaths attributed to cancer of the prostate appears to have reached a steady level.

No special occupations have been found to which the increase in the total of cases of cancer of the lung can be attributed; rural workers show an increase which is not much less than that in the general population.

No evidence has been found that tarring of roads has affected the incidence of cancer of the lung upon the general population. Such data as are available suggest that coal tar in the atmosphere, whether derived from roads, domestic chimneys, or any other source, does not readily give rise to cancer of the lung. Cotton-mule spinners show an especially small liability to cancer of the lung although they inhale air sprayed with an oil which produces cancer of the skin.

Improvements in diagnosis must have led to the detection of a larger proportion of the existing cases of cancer of the lung; whether there has been an actual increase in these cases cannot be decided from the data presented here, but a source of evidence on this question is suggested.

We are indebted to the Registrar-General for the data considered in this

paper, and also for kindly permitting us to use some figures which have not yet been officially made public. We have received much assistance in the classification of occupations from some members of the Staff of the General Register Office, to whom we wish to express our gratitude. We wish to thank also Dr J. C. Bridge, Senior Medical Inspector of Factories, for information upon various matters, and especially upon silicosis. We are greatly indebted to Miss L. D. Henderson for much assistance in carrying out the calculations.

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Note. No attempt is made in this paper to review the statistical literature of cancer of the lung. See G. M. Bonser (1934), *J. Hygiene*, **34**, 218.

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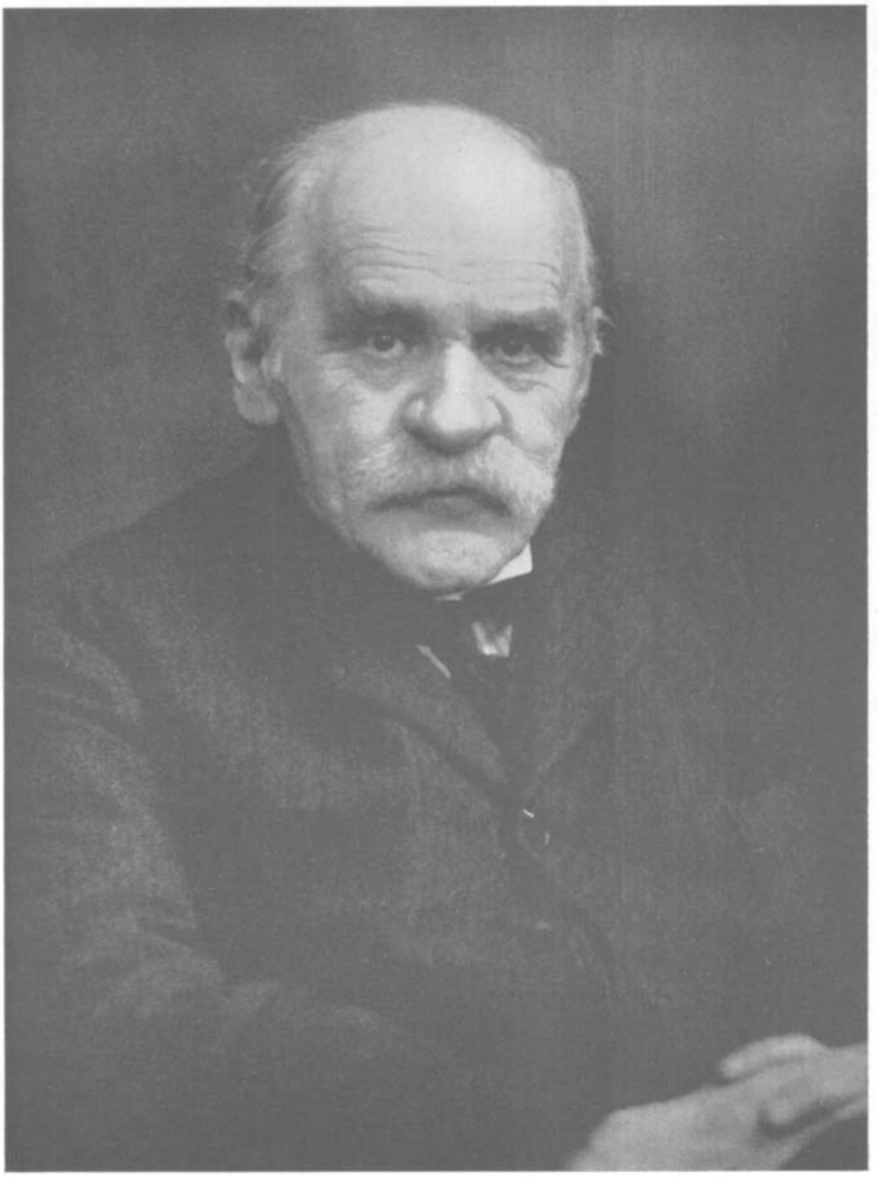
(*MS. received for publication* 17. III. 1936.—Ed.)



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This number of *The Journal of Hygiene* is dedicated to his memory as an outstanding man of science, Co-Founder of the *Journal* and Co-Editor for thirty-six years.

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https://doi.org/10.1017/S0022172400043618 Published online by Cambridge University Press