

# A survey of occupational cancer in the rubber and cablemaking industries: results of five-year analysis, 1967-71

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**Fox, A. J., Lindars, D. C., and Owen, R. (1974).** *British Journal of Industrial Medicine*, 31, 140-151. A survey of occupational cancer in the rubber and cablemaking industries: results of five-year analysis, 1967-71. A mortality study of 40 867 subjects employed in the rubber and cablemaking industries on 1 February 1967 is reported. No evidence is found of a continued excess risk of neoplasms of the bladder in people who entered the industry after 1949. For those employed before that date, during the period when known bladder carcinogens were in use, the SMR is higher than predicted, indicating that men are still dying with occupationally induced tumours.

An excess of all neoplasms was noted in the five years of the study. In certain sections of the industry (tyre manufacture, belting hose rubber with asbestos, and flooring industry) there is a particular excess of bronchial carcinoma. In those sections which use asbestos such an excess is not altogether surprising, but this does not apply to the tyre industry. The latter industry is sufficiently large (16 035 men in the study compared with 4 350 in the belting, hose rubber with asbestos, and flooring industry) for attention to be focused on particular operations. Two job groups are found to share the excess: moulding, press, autoclave, and pan curen; and finished goods, packaging, and despatch. Job selection may play a part in the latter, as the work is generally considered suitable for older and perhaps less healthy people.

Crude analyses have been undertaken to indicate whether the excesses are due to regional differences or to the population comprising an abnormally high proportion of smokers. No excesses are found in other smoking-related diseases. Although the effects of differences in smoking habit and regional differences cannot be ruled out, the indications are against these factors being the primary cause.

The difficulties of this type of study are discussed. It is emphasized that the results can be used only as an indication of a problem area and the type of further study required. A more exact study would concentrate on five-year cohorts of people who left the industry between 1940 and 1960. A study of five-year cohorts of people who entered the industry in the same period would also be valuable. An attempt has been made to perform the latter, but it would be hazardous to draw too many conclusions from this because the population comprises those who 'survive' in the industry until 1967.

Bladder cancer as an occupational hazard was first recognized by Rehn (1895). Reports of cases in the dyestuffs and chemical industries continued to

appear, and in 1949 the Association of British Chemical Manufacturers sponsored an investigation into the problem. The report (Case, Hosker, McDonald, and Pearson, 1954) showed that an increase in bladder tumours was associated with

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exposure to benzidine,  $\alpha$ -naphthylamine, and  $\beta$ -naphthylamine. The carcinogenicity of  $\beta$ -naphthylamine had already been demonstrated (Hueper, Wiley, and Wolfe, 1938). In 1953 papilloma of the bladder occurring in certain occupations was prescribed for benefit under the Industrial Injuries Act, and in 1967 the Carcinogenic Substances Regulations brought these chemicals under strict control. Papilloma of the bladder is a term referring to primary neoplasm of the epithelium lining the urinary bladder. Such tumours may or may not be malignant from the earliest moment of detection.

During the investigation by Case *et al.* (1954) a study was made of records of the County Borough of Birmingham, selected because, although it was a large industrial city, it did not have a large dyestuff industry. A discovery was made that many cases of bladder tumour had arisen in workers at one large rubber works. Concurrently with this discovery it was noted that cases of bladder tumour had arisen in makers of rubber-compounding chemicals for use as anti-oxidants. These events were recorded by Case and Hosker (1954) and drew attention to tumours of the urinary bladder as an occupational disease in the rubber industry in England and Wales.

Meanwhile in 1949 the chemical manufacturers had already drawn the attention of rubber manufacturers to the presence of carcinogens in certain additives, and the use of these compounds was discontinued. All naphthylamines were withdrawn from that date, but benzidine continued in some sections of the industry up to 1956 (Parkes, 1964). The Rubber Manufacturers Employers' Association (now the British Rubber Manufacturers' Association) established a health unit in 1957 to provide cyto-diagnostic facilities for exposed workers, and an explanatory booklet for workers was published ('Papilloma of the Bladder in the Rubber Industry 1961'), similar to one published nearly 10 years earlier by the Association of British Chemical Manufacturers.

Davies (1965) reported on the increased risk of bladder cancer in workers in electric-cable manufacture, in which rubber was used. A survey of the rubber and cablemaking industry was carried out by HM Factory Inspectorate in 1965. The objectives of the survey were twofold: to establish where certain defined substances containing carcinogens had been used, and to ensure that they were not currently in use; and, where they had been used, to arrange that both present and past employees possibly exposed to bladder carcinogens should receive advice to undergo a screening test (exfoliative cytology of the urine).

In the same year (1965) the Advisory Panel of the Senior Medical Inspector of Factories (now Chief Employment Medical Adviser) on occupational cancer gave approval for a mortality study of the rubber and cablemaking industries to compare the

patterns of mortality in three exposure groups, namely:

- (A) men employed in factories which used known carcinogenic compounds and men who entered those factories before 1 January 1950;
- (B) men employed in factories which used known carcinogenic compounds and who entered those factories after 31 December 1949; and
- (C) men employed in factories which had never used known carcinogenic compounds.

The results of a first analysis of this study are reported in this paper.

**Method**

On 1 February 1967, a census was taken of all men aged between 35 and 65 years employed in the rubber and cablemaking industries. In Great Britain 381 firms were identified by the Inspectorate and all co-operated in the census (HM Chief Inspector of Factories, 1968). Census

**TABLE 1**  
**CODES FOR LABELLING INDUSTRIES AND JOBS**

<i>Industry code</i>	<i>Type of industry</i>
1	Tyres
2	Tyre remoulds and retreads
3	Cables and electrical goods
4	Adhesives, rubber solutions, and sealing compounds
5	Clothing, rubberized textiles, rubberized hair and carpeting
6	Belting, hose rubber with asbestos, flooring
7	Footwear and footwear supplies except adhesives
8	Printing supplies
9	Surgical and medical goods and gloves
10	Ebonite and Vulcanite
11	Sponge rubber, rubber with plastic, crêpe rubber, etc.
12	Other rubber (brushes, sports goods and toys)
13	Mouldings, motor accessories and mechanicals
<i>Job code</i>	<i>Type of job</i>
1	Crude material storeman
2	Compounding, weighing, reforming, washing, etc.
3	Latex mixing, frothing, dipping
4	Extruding, calendaring, spreading, etc.
5	Component building, preparation, assembly, etc.
6	Moulding, press, autoclave, pan cureman
7	Inspection, painting
8	Finished goods, stores, packaging despatch
9	Site workers, general truck drivers, etc.
10	Engineering and building maintenance
11	Canteens
12	Factory operating staff
13	Commercial staff
14	Engineering staff
15	Technical staff

cards were completed for 49 068 subjects; 7 087 cards were rejected for various reasons, e.g., they did not fall into the correct age range; they were female; they were not of UK origin, or because they had not worked for one year in the industry. Details of the remaining 41 981 persons considered suitable for the study were sent to the National Health Service central registers in England and Wales, and in Scotland. Of these, 40 867 (97.35%) were traced to form the population for the study of mortality and, eventually, cancer registration. A summary of a preliminary analysis was reported by Lloyd Davies (1971).

In the following analysis deaths in the three groups defined above are contrasted. It has also been possible to make a comparison between different sections of the industries, and between occupations (industrial groups and job groups, Table 1). Statistical comparisons are made between observed and expected deaths. The expected deaths are, in the main, calculated using the England and Wales sex-age-standardized death rates published annually by the Registrar General (1967-70). The 1971 death rates are preliminary estimates provided by the Registrar General in personal communication. In several tables non-age-standardized death rates have been used in order to focus attention on particular subgroups. Significant findings have subsequently been confirmed or disproved using age-standardized death rates. In this way we limit the number of statistical tests performed and reduce the likelihood of finding significant results due to chance. A comparison between observed and expected values is made by assuming a Poisson distribution with the mean equal to the expected values. Pearson and Hartley (1962) give the probabilities of individual terms of the Poisson distribution. For a mean greater than 15.0 the normal approximation to the Poisson distribution has been assumed. An attempt is made to investigate the possible role of smoking habits by comparing the standardized mortality ratios (SMR) for carcinoma of the bronchus with those for other smoking-related

diseases. Differences with a likelihood of less than 0.05 being due to chance are considered to be statistically significant. Many of the findings attain higher significance and the probabilities are given.

Causes of death are classified according to the *International Classification of Diseases* (1967). In the initial analysis (Table 2) cancers of certain specific sites were included as these were thought possibly to be associated with occupation.

#### Healthy population

The population studied comprises people who were in employment as at 1 February 1967. The national population, with whom comparisons are made, includes people who are sick and unable to work. The effect on the comparison is such that in the first year of the study a low SMR is observed (Table 2). So that this does not affect our findings the deaths in 1967 are not included when statistical comparisons are being made. The observed and expected deaths for 1967 are, however, given in Table 2.

#### Results

An important finding in the overall deaths (observed, expected, and SMR) for the main causes of interest (Table 2) is that there is a significant excess of all neoplasms ( $p < 0.001$ ).

#### Carcinoma of bladder (ICD 188.0-188.9)

From Table 2 it can be seen that in the last four years of the study 23 deaths from bladder tumours have been observed as compared with 20 expected deaths. Table 3 categorizes these deaths according to exposure group. Although the numbers are small, the excess of deaths due to carcinoma of the bladder are occurring primarily in those subjects who were

TABLE 2  
OBSERVED AND EXPECTED DEATHS FOR CAUSE GROUPS OF INTEREST GIVEN FOR EACH YEAR OF SURVEY  
(Because of the effect of selecting a working population 1967 is excluded from comparisons.)

Cause group (ICD number)	1967*		1968		1969		1970		1971		Total 1968-71		
	Obs	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs	Exp	Obs	Exp	SMR
All neoplasms (140-239)	83	106	147	128	166	138 <sup>1</sup>	175	148 <sup>1</sup>	170	157	659	572 <sup>3</sup>	115
Ca. oesophagus (150)	3	3	2	3	1	3	—	4	6	4	10	14	71
Ca. liver primary (155)	2	1	—	1	—	1	1	1	—	1	1	4	25
Ca. bladder (188)	2	3	6	4	8	5	5	5	4	6	23	20	115
Ca. other urinary organs (189)	1	2	3	2	1	3	2	2	3	3	9	10	90
Ca. brain (191)	1	3	5	3	5	3	3	3	1	3	14	13	108
Ca. liver as secondary (197.7-197.8)	—	1	1	1	3	1	2	+	1	+	6	+	+
Leukaemia (204-207)	1	2	6	3	1	3	6	3	1	3	14	13	108
Accidents (800-999)	10	20	14	22	22	22	18	22	23	22	77	88	88
Other causes	149	250	281	310 <sup>1</sup>	282	354 <sup>3</sup>	362	370	366	391	1 293	1 425 <sup>3</sup>	91
All causes	242	376	442	460	470	514	555	541	559	571	2 029	2 085	97
Overall SMR	64.4		96.1		90.4		102.6		97.9				

\*Only 11 months from 1 February

<sup>1</sup>Expected values not calculated

<sup>2</sup> $p < 0.05$ ; <sup>3</sup> $p < 0.01$ ; <sup>4</sup> $p < 0.001$

TABLE 3

OBSERVED AND EXPECTED DEATHS FOR NEOPLASM OF BLADDER (ICD 188.0-188.9) SUBCATEGORIZED ACCORDING TO EXPOSURE GROUP

Exposure group	Deaths 1968-71			
	Obs.	Exp.	SMR	
A	11	8.5	130	NS
B	7	7.2	97	NS
C	5	4.4	114	NS
Total	23	20.0	115	NS

exposed to known bladder carcinogens before 1950. The excess observed here is smaller than that found previously (Case and Hosker, 1954). It should be remembered, however, that since our population was still in the industry on 1 February 1967 their last exposure was at least 17 to 22 years before death and their first exposure might have been considerably earlier. Veys (1969) observed an average latent period of 17.6 years from first exposure; in the chemical industry Case *et al.* (1954) found a latent period of 17.8 years with a standard deviation of 7.18 years. Both these estimates are based on 'censored data'<sup>1</sup> in that some people had not yet developed tumours when the estimates were made. It is, therefore, quite likely that the SMR for group A will converge to that for the other exposure groups because the effect of the excess of tumours caused by exposure to known carcinogens will be diminishing. The SMRs for exposure groups B and C provide no evidence that there is still an excess risk of bladder tumours in the industry. Although this is not conclusive evidence that there is no risk, it would suggest that any excess is small relative to that previously observed.

<sup>1</sup>The data are right-censored in the statistical sense (see, for example, Peto (1973))

#### All neoplasms (ICD 140.0-239.9)

Table 4 gives the number and percentage of people included in each of the exposure groups and the number of observed and expected deaths due to all neoplasms (ICD 140.0-239.9). As can be seen from the table, the significant excess of cancer deaths is observed primarily in those falling into exposure group B. This difference might be explained partially by the later analysis of deaths according to the years in which subjects entered the industry.

#### Analysis of different sections of the industry

Observed deaths (1968-71) are given in Table 5 for carcinoma of the bronchus, carcinoma of the bladder, other neoplasms, and all other causes of death. These have been broken down according to industrial group (Table 1) and crude expected values have been calculated to indicate the sectors of the industry meriting further study.

The expected values in Table 5 are obtained by multiplying the expected values for each cause of death in the total rubber and cablemaking industry by the proportion of the initial population who were in the particular sector of the industry. An example is given below the table. This method of calculation is obviously crude because it takes no account of differences in age structures between sectors of the industry. As will be seen from Table 6, the assumption proves reasonably valid for industrial group 1 (tyres).

**Industrial group 1 (tyres)** From Table 5 it is clear that further study of industrial group 1 is required. In Table 6 accurate expected values are calculated on the basis of 'man years of risk'. From this Table it becomes evident that in industrial group 1 there is a significant excess of all neoplasms (273 observed as compared with 217.4 expected,  $p < 0.001$ ) and of carcinoma of the bronchus (131 observed as compared with 97.8 expected,  $p < 0.001$ ). Expected values for ischaemic heart disease, chronic bronchitis

TABLE 4

OBSERVED AND EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIO FOR DEATHS DUE TO ALL NEOPLASMS (ICD 140.0-239.9) SUBCATEGORIZED ACCORDING TO EXPOSURE GROUP

Exposure group	Number (%)	Deaths 1968-71			
		Obs.	Exp.	SMR	
A	12 781 (31.3%)	237	233	102	NS
B	18 116 (44.3%)	274	212	129	$P < 0.001$
C	9 970 (24.4%)	148	126	117	NS
Total	40 867	659	572	115	$P < 0.001$

TABLE 5  
A CRUDE GUIDE TO SECTORS OF INDUSTRY MERITING FURTHER STUDY INCLUDING ALL DEATHS OBSERVED 1968-71

Industrial group	Carcinoma of bronchus		Neoplasm of bladder		Other neoplasms		All neoplasms		All other causes		All causes of death		Total population 1 Feb. '67
	Obs.	Exp.*	Obs.	Exp.*	Obs.	Exp.*	Obs.	Exp.*	Obs.	Exp.*	Obs.	Exp.*	
1	131	100 <sup>a</sup>	7	8	135	116	273	224 <sup>a</sup>	510	594 <sup>a</sup>	783	818	16 035
2	7	6	—	—	8	7	15	13	27	34	42	47	912
3	13	16	3	1	19	18	35	35	90	92	125	128	2 506
4	5	5	—	—	3	6	8	11	30	29	38	40	777
5	14	11	—	1	19	13	33	25	66	67	99	92	1 811
6	44	27 <sup>a</sup>	2	2	41	32	87	61 <sup>a</sup>	177	161	264	222 <sup>a</sup>	4 350
7	14	19	2	1	27	21	43	41	98	110	141	151	2 958
8	4	2	—	—	6	2 <sup>1</sup>	10	4	8	12	18	16	315
9	5	4	2	—	7	5	14	9	29	25	43	34	671
10	5	3	—	—	4	4	9	7	12	18	21	25	499
11	6	8	1	1	9	9	16	18	46	46	62	64	1 255
12	4	3	1	—	3	3	8	6	14	16	22	22	438
13	49	52	5	4	54	60	108	116	263	309 <sup>a</sup>	371	426 <sup>a</sup>	8 340
Total	301	256	23	20	335	296	659	572	1 370	1 514	2 029	2 086	40 867

\*Expected deaths based on the proportion of people in particular industrial groups multiplied by the total number of deaths expected for cause of interest, e.g., carcinoma of bronchus, group 1: Expected =  $256 \times \frac{16\ 035}{40\ 867} = 100.4$

<sup>1</sup>P < 0.05; <sup>a</sup>P < 0.01; <sup>a</sup>P < 0.001

and other respiratory diseases have been calculated from 1970 age-standardized national rates; otherwise annual rates have been used.

In Table 7 the observed and expected deaths due to carcinoma of the bronchus are calculated for each age group in exposure groups A and B. Figures for exposure group C are not given because of the limited number of 'man years at risk'. These can, however, be obtained by subtraction from the total tyre sector. The outstanding feature in this Table is a significant excess in exposure group B and particularly in age group 55-64 (observed 40 as com-

pared with an expected 21.13, P < 0.001). There is a slight but not statistically significant excess in groups A and C.

**Industrial group 6 (belting, hose rubber with asbestos, flooring)** In Table 5 the relatively crude calculation of expected values suggests that industrial group 6 (belting, hose rubber with asbestos, and flooring) merits further study. The estimated excess incidence of carcinoma of the bronchus and of causes of death other than neoplasm is confirmed by the more accurate calculation of age-standardized expected

TABLE 6  
OBSERVED AND AGE-STANDARDIZED NATIONALLY EXPECTED DEATHS IN TYRE SECTOR OF RUBBER AND CABLEMAKING INDUSTRIES 1968-71

	All neoplasms (ICD 140-239)	Carcinoma of bronchus (ICD 162.1)	Carcinoma of bladder (ICD 188)	Bronchitis and emphysema (ICD 490-492*)	Other respiratory Disease (ICD 460-519* not 490-492)	Ischaemic heart disease (ICD 410-414*)	All other causes†	All causes of death
Observed	273	131	7	43	24	246	197	783
Expected	217.4	97.8	7.5	52.3	43.8	264.2	195.0	786.4
SMR	126 <sup>a</sup>	134 <sup>a</sup>	93	8.2	55	93	101	99.6

\*Expected deaths based on 1970 rates

†Expected deaths calculated by subtraction

<sup>a</sup>P < 0.001

TABLE 7  
DEATHS DUE TO CARCINOMA OF BRONCHUS, OBSERVED 1968-71 IN TYRE INDUSTRY RELATED TO AGE AND EXPOSURE GROUP

Age group	Exposure group				Total tyre sector	
	A		B		Obs.	SMR
	Obs.	SMR	Obs.	SMR		
35-44	1	196	2	108	4	160
45-54	11	135	13	131	24	129
55-64	34	98	40	189 <sup>3</sup>	75	132 <sup>1</sup>
65-70	19	132	9	163	28	140
Total	65	112	64	167 <sup>3</sup>	131	134 <sup>3</sup>

<sup>1</sup>P < 0.05; <sup>3</sup>P < 0.001

values based on national rates as given in Table 8. Since this group comes into contact with asbestos, as well as other chemicals, these results are not altogether surprising. Clearly, further study of this group would be required, in particular to discover the levels of asbestos to which people in this industry are exposed.

**Industrial group 8** An excess incidence in industrial group 8 (printing supplies) of neoplasms, other than those of the bronchus and bladder, is suggested in Table 5. This excess is, however, not confirmed by national age-standardized comparisons. As the number of people in this group is small it would in any case be difficult to draw conclusions.

#### Possible influence of smoking habit and/or urban effects

When studying a population with an excess incidence of bronchial carcinomas two possible explanations immediately spring to mind. The first is related to the smoking habits of the population (Royal College of Physicians, 1971) and the second is related to the effect of the area in which the factories

are situated (Howe, 1963; Registrar General, 1967). Both these factors are extremely difficult to rule out as causes unless detailed histories have been recorded. No record of the distribution of smoking habits was made in the population under study.

One method of estimating the role played by smoking habit and by urban effect is to consider the relative incidence of other smoking and urban-related diseases, such as chronic bronchitis and emphysema (ICD 490-492), other respiratory disease (ICD 460-519 excluding 490-492), ischaemic heart disease (ICD 410-414), and other neoplasms (ICD 140-239 excluding 162.1). In Table 9 the observed deaths in the tyre industry are compared with those for the remainder of the rubber and cablemaking industry for these cause groups. In an attempt to account for urban effects comparison is made with 1970 age-standardized death rates for Merseyside, an area with one of the largest urban effects in the United Kingdom. When studying this Table one should remember that we have shown an overall excess of neoplasms in the whole rubber and cablemaking industry and particularly an excess of bronchial carcinoma. Table 9 shows that although

TABLE 8  
MORTALITY PATTERN IN BELTING, HOSE RUBBER WITH ASBESTOS, FLOORING (1968-71) ACCORDING TO AGE GROUP

Age group	Carcinoma of bronchus			All other neoplasms			Other causes of death			All causes of death		
	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR
35-44	2	0.74	270	6	1.87	321	14	8.78	159	22 <sup>3</sup>	11.39	193
45-54	5	4.95	101	8	6.79	118	41	32.23	127	54	43.97	123
55-64	22 <sup>1</sup>	14.43	152	19	15.13	126	84	75.40	111	125	104.96	119
65-74	13 <sup>2</sup>	5.57	233	10	6.99	143	40	37.16	108	63	49.72	127
Total	42 <sup>3</sup>	25.67	164	43 <sup>1</sup>	30.39	140	179	153.58	117	264 <sup>3</sup>	210.04	126

P < 0.05; <sup>2</sup>P < 0.01; <sup>3</sup>P < 0.001

TABLE 9  
COMPARISON OF OBSERVED AND EXPECTED DEATHS IN TYRE INDUSTRY WITH THOSE FOR REMAINDER OF RUBBER AND CABLEMAKING INDUSTRY (Expected deaths based on 1970 age-standardized rates for Merseyside conurbation)

	(a) All tyre sector			(b) Tyre sector only, subjects involved with autoclave, moulding, etc. (Job 6)			(c) Remainder of rubber and cablemaking industry			Rubber and cablemaking industries (Total a + c)		
	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR
Carcinoma of bronchus	131	143.4	91.4	15	12.2	123.0	170	231.2	73.5	301	374.6	80.4
All other neoplasms	142	140.9	100.8	14	12.0	116.7	216	227.5	94.9	358	368.4	97.2
All neoplasms	273	284.3	96.0	29	24.2	119.8	386	458.7	84.2	659	743.0	88.7
Bronchitis and emphysema	43	78.6	54.7	3	6.5	46.2	77	129.6	59.2	120	208.2	57.6
All other respiratory disease	24	62.7	38.3	3	5.2	57.7	46	103.1	44.6	70	165.8	42.2
Ischaemic heart disease	246	302.7	81.3	16	25.8	62.0	420	486.8	86.3	666	789.5	84.4
All other causes	197	229.9	85.7	9	19.6	45.9	317	373.3	84.9	514	603.2	85.2
All causes of death	783	958.2	81.7	60	81.3	73.8	1 246	1 551.5	80.3	2 029	2 509.7	80.8

the SMR for carcinoma of the bronchus in the tyre sector is higher (approximately 24% higher) than that for the remainder of the rubber and cablemaking industry, the SMR for other smoking and urban-related disease is approximately the same. In particular, bronchitis and emphysema, whose rates are usually highly correlated with those for bronchial carcinoma, is estimated at approximately 8% lower for the tyre sector as compared with the remainder of the industry. This would suggest that neither the urban effect nor a smoking effect is likely to be the primary cause of our observed excess. This point is magnified if one looks at job 6, in the tyre sector (moulding, press, autoclave, and pan cureman), which is also given in Table 9. The SMR for carcinoma of the bronchus is estimated to be

approximately 65% higher than in the industry excluding the tyre sector whereas for bronchitis and emphysema it is estimated to be approximately 22% lower. It should be noted that smoking habit and urban effect are not so easily ruled out in industries 6 and 8. This is because, as is shown in Table 8 for industry 6, the SMRs for most diseases in these groups are raised. We have, however, already emphasized that these industries should be studied in greater depth.

#### Guide to jobs affected

When the population was set up in 1967 details of job as at 1 February 1967 were recorded and categorized as shown in Table 1. The difficulties of drawing conclusions from this classification ought

TABLE 10  
AGE-STANDARDIZED COMPARISONS BETWEEN OBSERVED AND EXPECTED DEATHS (1968-71) FOR CARCINOMA OF BRONCHUS, OTHER NEOPLASMS AND OTHER CAUSES OF DEATH IN MOULDING, PRESS, AUTOCLAVE AND PAN CUREMAN IN THE TYRE SECTOR

Age at death	Carcinoma of bronchus			Other neoplasms			Other causes of death			All causes of death		
	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR
35-44	—	0.25	—	2	0.66	303	—	3.08	—	2	3.99	50
45-54	4	1.75	286	5	2.37	211	3	12.24	25	12	16.36	73
55-64	8	5.05	158	7	5.64	124	26	25.99	100	41	36.68	112
65-70	3	1.33	226	—	1.58	—	2	7.09	28	5	10.00	50
Total	15 <sup>1</sup>	8.37	179	14	10.25	137	31	48.40	64	60	67.02	90

<sup>1</sup>P < 0.05

Note: For 'other causes of death' in the 45-54 and 65-70 age groups there are significant deficiencies of deaths.

TABLE 11

AGE-STANDARDIZED COMPARISONS BETWEEN OBSERVED AND EXPECTED DEATHS (1968-71) FOR CARCINOMA OF BRONCHUS, OTHER NEOPLASMS AND OTHER CAUSES OF DEATH IN FINISHED GOODS, STORES AND PACKAGING-DESPATCH MEN IN THE TYRE SECTOR

Age at death	Carcinoma of bronchus			Other neoplasms			Other causes of death			All causes of death		
	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR
35-44	—	0.11	—	1	0.29	344	2	1.44	139	3	1.84	163
45-54	2	0.96	208	3	1.30	231	10	6.27	159	15 <sup>1</sup>	8.53	176
55-64	10 <sup>1</sup>	4.19	239	4	4.68	85	18	21.65	83	33	30.52	108
65-70	1	1.49	67	2	1.77	113	8	9.08	88	11	12.34	89
Total	13 <sup>1</sup>	6.75	193	10	8.04	124	39	38.44	101	62	53.24	116

<sup>1</sup>P < 0.05

to be emphasized at this stage. Since the jobs are defined as at 1 February 1967, it is likely that some of the people who were in a particular job in, say, 1950 were in other jobs in 1967. It is also probable that a large proportion would have left the industry before 1967, but this factor is dealt with later in the discussion. The effect of job rotation is such that, if there is an increased risk attached to a particular job, this risk will not be as overt as it might be if a proper cohort study had been undertaken. Also if there is a tendency for older and perhaps less healthy people to be given a particular job, this job will appear to have a high risk attached to it. These factors must be borne in mind when studying the industry with a view to detecting the jobs in which most risk is incurred. The tyre sector has been screened crudely as the total industry was screened (Table 5). This crude analysis indicates that two job groups merit much closer attention. These are job

6 (moulding, press, autoclave, and pan cureman) and job 8 (finished goods; stores, packaging, despatch). The results of detailed age-standardized comparisons for these two groups are given in Tables 10 and 11. Although there are marginally significant excesses ( $P < 0.05$ ), the numbers here are extremely small. The proportion of bronchial carcinomas are, however, extremely high (25% and 21% of all deaths in jobs 6 and 8 respectively). It should be pointed out with respect to job 8 that by its nature this job attracts older and also perhaps less healthy people. This factor may play an important role in the causation of the excess in this group. Clearly, as well as studying the whole tyre industry particular attention should be paid to these jobs.

#### Year of entry into the industry

In Table 12 the mortality pattern in industry 1 is compared with that for the remainder of the rubber

TABLE 12

COMPARISON OF MORTALITY WITH YEAR OF ENTRY INTO INDUSTRY

(Figures in parentheses are the proportion of population who died 1968-71 and proportions of deaths from bronchial carcinoma and from other neoplasms.)

	Industry 1—tyres				Remainder of rubber and cablemaking industry			
	Population 1967	All deaths 1968-71	Bronchial carcinoma 1968-71	All other neoplasms 1968-71	Population 1967	All deaths 1968-71	Bronchial carcinoma 1968-71	All other neoplasms 1968-71
Pre 1940	2 731	205 (7.5)	23 (11.2)	38 (18.5)	3 245	226 (7.0)	23 (10.2)	45 (19.9)
1940-44	934	43 (4.6)	11 (25.6)	7 (16.3)	981	57 (5.8)	10 (17.5)	10 (17.5)
1945-49	3 402	182 (5.3)	31 (17.0)	33 (18.1)	3 392	159 (4.7)	22 (13.8)	26 (16.4)
1950-54	2 848	127 (4.5)	28 (22.0)	28 (22.0)	3 889	191 (4.9)	28 (14.7)	30 (15.7)
1955-59	2 683	107 (4.0)	20 (18.7)	10 (9.3)	4 494	216 (4.8)	35 (16.2)	34 (15.7)
1960-64	2 596	84 (3.2)	13 (15.5)	17 (20.2)	6 278	278 (4.4)	36 (12.9)	57 (20.5)
1965-66	841	35 (4.1)	5 (14.3)	9 (25.7)	2 451	119 (4.9)	16 (13.4)	14 (11.8)
Total	16 035	738	131 (16.7)	142 (18.1)	24 832	1 246	170 (13.6)	216 (17.3)



and cablemaking industry according to the year in which individuals entered the industry. The figure illustrates the differences between these two groups with respect to the proportion of deaths attributed to bronchial carcinoma. Although the difference between these proportions is small for those who entered before 1940 or after 1955, the proportions for those who entered between these dates differ widely. This is consistent with the concept that a lung carcinogen is being used in this sector of the industry and those subjects who were first exposed 15 years or more ago are at most risk because of possible time lags before cases are observed. People who were in the industry before 1940 are, by definition, a survivor group and probably older people.

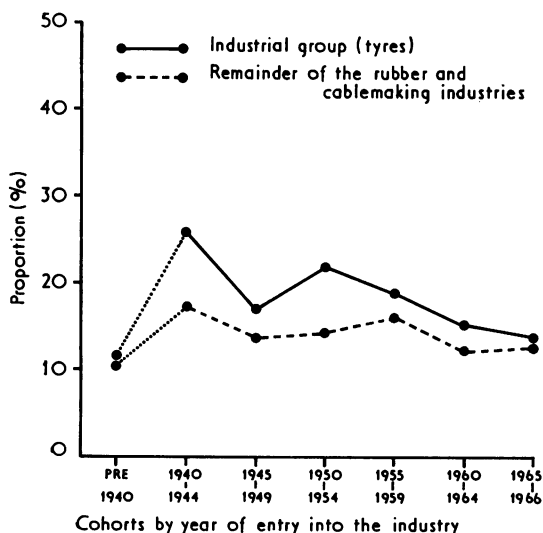


FIGURE Proportion of all observed deaths found to be due to lung cancer according to year in which subjects entered the industry.

The effect of lung carcinogen would consequently be less overt in this group because the deaths attributed to the carcinogen would form a smaller proportion of all deaths.

Table 13 confirms these findings by giving age-standardized expected values for those subjects who entered the industry between 1950 and 1954. Although the overall SMR for this group is 102, the SMR for carcinoma of the bronchus is 184 and for other neoplasms is 148. These findings emphasize the need for a properly designed cohort study, the cohorts being based both on year of entry into the industry and subsequently on year of departure from the industry.

The results nevertheless indicate that other carcinogens might be in use in the rubber and cablemaking industry. There is an overall significant excess of neoplasm deaths (Tables 2 and 4). The proportions of different cancers observed between 1968 and 1971 are similar for the total industry to those observed nationally in 1969 but there is an increase in numbers. Although this apparent excess occurs throughout the industry, there would also appear to be particular hazards related to the tyre and the belting, hose rubber with asbestos, and flooring industries. These will require further more detailed study.

Since the tyre industry provides approximately 10% of the total population and an overall cancer risk is found, it is not entirely surprising that a significant excess is demonstrable in this sector. The risk of neoplasms in the tyre industry is found, however, to be approximately 14% higher than that for the remainder of the rubber and cablemaking industry, and in particular for carcinoma of the bronchus it is found to be approximately 24% higher (Table 9). In this sector the two job groups which appear to contribute most to this excess are moulding, press, autoclave and pan cureman, and finished goods, stores and packaging despatch. In the former group the excess rate for all neoplasms is

TABLE 13  
MORTALITY PATTERN (DEATHS OBSERVED 1968-71) BY AGE AT DEATH FOR SUBJECTS WHO ENTERED THE TYRE INDUSTRY BETWEEN 1950 AND 1954  
(Note comments in the text re 'survivor' population and the incompleteness of this cohort.)

Age group	Carcinoma of bronchus			All other neoplasms			Other causes of death			All causes of death		
	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR	Obs.	Exp.	SMR
35-44	—	0.53	—	4	1.37	292	4	6.36	63	8	8.26	97
45-54	8	3.41	235 <sup>1</sup>	9	4.70	191	19	24.28	78	36	30.39	118
55-64	16	8.63	185 <sup>1</sup>	13	9.67	134	39	44.54	88	68	62.84	108
65 +	4	2.65	151	2	3.24	62	9	16.85	53	15	22.74	66
Total	28	15.22	184	28	18.98	148	17	92.03	77	127	124.23	102

<sup>1</sup>p < 0.05

42% and for bronchial carcinoma is 67% as compared with the rest of the industry excluding the tyre sector. Interpretation of the findings for the latter group is more difficult because of the problem of job selection.

No evidence was found to suggest that this excess might be attributed to an urban effect or to smoking. The death rates for urban and smoking-related causes, in particular for bronchitis and emphysema, in the tyre industry is approximately the same as for the remainder of the rubber and cablemaking industry.

From Table 5 it can be seen that the belting, hose rubber with asbestos, and flooring industry is approximately one quarter the size of the tyre industry. This makes detailed analysis at this relatively early stage in the study much more difficult. There would, however, appear to be approximately 54% more neoplasms and, in particular, 71% more bronchial carcinomas than expected by national age-standardized rates. The overall standardized mortality ratio is also high in this sector, making it more difficult to exclude possible urban and smoking effects (Table 8).

An apparent excess in Table 6 in the printing supply industry is not confirmed by more detailed analysis. However, the sample is extremely small (only 315 individuals). Mancuso (1949), in a study of death certificates for the State of Ohio, noted a higher death rate for malignancies of the brain, central nervous system, and respiratory system among employees of the rubber and plastic industries. Guralnick (1963), in a national study of mortality by industry and occupation as recorded on the death certificate, also observed a general excess for all neoplasms and in particular an excess of malignant neoplasms of the respiratory system. The first prospective study to report an excess of malignant neoplasms of the respiratory system was that undertaken by Mancuso, Ciocco, and El-Attar (1968) when they monitored from 1940 to 1964 a cohort who had been in employment in 1938 and 1939 in a particular company manufacturing rubber products. Of a total of 1 568 white male employees who were studied in the population, 19 deaths due to carcinoma of the bronchus, trachea, and lung were observed. None of these occurred among the office employees. Of the 19 deaths, 8 occurred in the compounding mill and callender department group. The average annual age at death rate for those 65 and over was found to be 799, as compared with a rate of 143 for the State of Ohio. A further three deaths due to carcinoma of the lung, all in the 25-44 age group, occurred among the curing and tyre building department.

An increase in the prevalence of lung cancer has been observed in a number of occupational groups, including uranium miners (Waggoner *et al.*, 1965)

and haematite miners (Boyd, Doll, Faulds, and Leiper, 1970); asbestos workers (Doll, 1955) and workers exposed to asbestos in the insulation industry (Selikoff, Churg, and Hammond, 1964); talc miners and millers (Kleinfeld, Messite, Kooyman, and Zaki, 1967); nickel smelters (Doll, 1958) and workers manufacturing chromates and chrome pigments (Bidstrup and Case, 1956); workers exposed to arsenic in vineyard spraying (Roth, 1958) and sheep-dip production (Merewether, 1944); men employed in coal distillation in the gas industry (Doll, 1952; Doll *et al.*, 1965); and newspaper workers in the printing industry (Moss, Scott, and Atherley, 1972; Greenberg, 1972). Some of these findings may be relevant to the present study. The lung cancer mortality in newspaper workers is reflected in the excess in printing supplies in this study, and emphasizes the need for a separate study of this group to be undertaken. Talc is extensively used in rubber manufacture and the possibility that this material has contributed to lung cancer mortality needs to be investigated. Those sections of the rubber industry which use asbestos may be experiencing an increased mortality attributable to asbestos. The role of aromatic hydrocarbons requires elucidation. Carbon black is a major raw material in the tyre industry, and is also used in the manufacture of printers' ink; it is known to absorb hydrocarbons during production (Falk and Steiner, 1952), but no increase in cancer mortality was found in carbon black workers by Ingalls (1950).

It is possible, therefore, that the findings reported in this paper represent no single cause. There may be synergism with a co-carcinogen, and an effect from smoking similar to the multiplicative effect found in asbestos workers (Selikoff, Hammond, and Churg, 1968; Berry, Newhouse, and Turok, 1972) may also be involved.

It must be emphasized that this study was designed to monitor a group of people who entered the rubber and cablemaking industry after the industry ceased to use known bladder carcinogens. It was thought that there might be related hazards and that these would be detected by this crude method. The population selected is as large as was considered to be practicable and covers the total industry. It is, therefore, a useful population for monitoring the prevalence of disease but *not* for measuring accurately the excess risks in each subgroup. This is evident from Table 11 where the number of people included in the study from several sectors of the industry is clearly too small for detailed epidemiological study. This is one reason why in particular the excess prevalence in the tyre industry, a large industry, is significant whereas that, for example, in sector 5, a small industry, is not significant when the excess in sector 5 would be estimated to be the greater of the two.

The population, consisting of those people in the industry as at 1 February 1967, comprises to a great extent a survivor population. Many people, for example, who were employed in the industry before 1954 will have left; also many will have died. Clearly this will affect any estimate of excess. Also included in the population are people who entered the industry as recently as 1965 and early 1966. In the light of the expected latent periods for several well-known occupational cancer hazards, it is unlikely that these people will have occupationally induced tumours from the industry under study. These people, therefore, have a dilution effect on any measure of excess. Similarly, jobs were recorded as at the first day in the study, and subsequent classifications do not account for job rotation. If excess risks are to be associated with particular jobs and it is desired to measure the extent of these, it is necessary to study cohorts of people according to periods exposed and year of first exposure. Unless there is a tendency for older and less healthy people to be given a particular job, the effect of not accounting for previous jobs is likely to decrease the difference in risks between jobs.

On the other hand, the information collected does not provide an entirely satisfactory estimate of the roles of urban effects and the possible effects of smoking habit. Although the indications are that these are not the primary cause of the excess, they cannot be entirely ruled out, particularly for the belting, hose rubber with asbestos, and flooring industry and the printing supply industry.

The evidence obtained is not conclusive and must be used only as the basis for hypotheses that can be tested in a further study. The evidence suggests that concern should centre on measuring the mortality rates in groups of people who left the industry between 1940 and 1966. These should be accompanied by detailed occupational and smoking histories if accurate measures of the excess are to be obtained.

This study of people who have left the industry should give an indication as to when the incidence of neoplasms increased. Initial attention must be given to specific jobs in the tyre industry and to the belting, hose rubber with asbestos, and flooring industry. The possibility of more than one causative factor being involved must be borne in mind.

A separate study is at present being conducted by the Rubber Manufacturers Association and the Department of Social Medicine at Birmingham University<sup>1</sup>.

We are indebted to many people who have assisted and advised in the running and analysis of this survey. In particular, Dr. G. Hill must receive much of the credit for preparing the survey for computer analysis. The Automatic Data Processing Section of the Department of Employment and Mr. J. Draper, in particular, have provided the necessary computer support.

No survey of this kind can be undertaken without the not inconsiderable assistance of the General Register Office for Scotland and the Office of Population Censuses and Surveys, who have traced almost all the people identified and subsequently notified causes of death. Dr. J. W. Donovan and Dr. J. A. Waterhouse have made several extremely useful comments on statistical aspects of early drafts of this report.

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<sup>1</sup>Reports of a possible lung cancer hazard in the rubber industry were first presented to the Department of Employment Industrial Health Advisory Committee in the autumn of 1972. These were based upon prima facie evidence of such a hazard arising from a Departmental study of the incidence of occupational bladder cancer in the rubber industry, but they did not support any final conclusion about the existence of a lung cancer hazard. Manufacturers concerned therefore agreed to support and finance a full epidemiological investigation which is now being carried out in collaboration with the Department of Social Medicine at Birmingham University. It is hoped that the investigation may be completed by the end of 1974, and an undertaking has been given that the detailed findings and conclusions will then be offered for publication.—EDITOR.

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