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Occupation and bladder cancer: a death-certificate study

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Summary Occupational statements on death certificates of 2,457 males aged 25-64 who died from bladder cancer in selected coastal and estaurine regions of England and Wales during 1965-1980 were studied.

Excess mortality was found for deck and engine room crew of ships, railway workers, electrical and electronic workers, shoemakers and repairers, and tobacco workers. An excess of cases also occurred among food workers, particularly those employed in the bread and flour confectionary industry or involved in the extraction of animal and vegetable oils and fats. Use of a job-exposure matrix revealed elevated risk for occupations in which most workers were exposed to paints and pigments, benzene and cutting oils.

Bladder cancer has been recognised as an occupational disease since the late part of the nineteenth century. The causal association with exposure to aromatic amines used in the chemical dyestuff and rubber industries has been well documented (IARC, 1990). Exposure to these agents has been curtailed since the 1960s. More recent epidemiological evidence suggests that exposure to other agents, such as coal combustion products, diesel and petrol exhaust fumes, cutting oils, chlorinated aliphatic hydrocarbons and creosote may entail a carcinogenic risk. Additionally, there is evidence of elevated risk among certain occupational groups such as painters, textile workers and shoemakers and repairers, but it is not clear which agents are responsible.

In England and Wales, analysis of the geographical distribution of bladder cancer mortality has indicated high mortality among males in some coastal and estuarine districts close to large industrialised centres (Dolin, 1992). High bladder cancer mortality among males in these areas may result from employment in industries which tend to be located close to the coast. The purpose of this study was to examine bladder cancer mortality in relation to occupation in coastal areas which have a high mortality rate.

Materials and methods

The study was centred on 59 administrative districts of England and Wales (Appendix I). These districts are located near the coast or estuaries, are close to urbanised centres with elevated mortality rates for bladder cancer, and have a sizable proportion of their workforce employed in the chemical, transport and port-related industries. The study region accounts for approximately 25% of the national workforce and includes parts of London, Bristol, Cardiff, Liverpool, South Tyneside, Cleveland and Humberside.

Cases consisted of 2,457 males aged 25-64 who died from cancer of the bladder during 1965-80 and whose usual place of residence was within the study region. Copies of death certificates for all cases were obtained from the Office of Population Censuses and Surveys (OPCS). Information on occupation and industry of usual employment was extracted from the death certificates and coded according to the 1970 Classification of Occupations (OPCS, 1970) and the Standard Industrial Classification (Central Statistical Office, 1968). Adequate details were available for 2,436 (99.1%) cases to be assigned to an occupation and 2,103 (85.6%) cases to an industry.

Data on the number of males employed in each occupation and industry, according to age and district of residence, was supplied by the OPCS Longitudinal Study Group. This information was based on the 1971 census in which questions were asked about a person's current employment or their most recent work if they were out of work (OPCS, 1988).

No information was available on the smoking status of cases. Because of the possibility that observed associations could be confounded by smoking, degree of urbanisation was used as a proxy measure of smoking and other non-occupational factors. Each district was categorised by degree of urbanisation (1-99,999; 100,000-249,999 and 250,000+ residents).

Indirect age standardisation was used to calculate for each occupation and industry a mortality ratio standardised for age and degree of urbanisation (SMR). The SMR denominators were calculated by multiplying age- and urbanisation-specific mortality rates by the age- and urbanisation-specific population estimates for each occupation and industry. Ninety-five per cent confidence intervals were calculated using tables of confidence limits for the mean of a Poisson distribution (Pearson & Hartly, 1976).

Assessment of risk associated with exposure to specific chemical agents was undertaken using a job-exposure matrix developed by Pannett and colleagues (Pannett *et al.*, 1985). Occupations were identified in which a high proportion of workers in 1950 were likely to have been exposed to a specific chemical agent. The observed and expected number of deaths for the selected occupations were summed and an SMR calculated.

Results

Tables I and II show observed and expected deaths and SMR for each occupation and industry. An excess of 25 cases was found among electrical and electronic workers, nine of which were among electricians and eight among electrical engineers. Six of the seven electrical and electronic occupations had an SMR above 100.

Elevated risk occurred among food, drink and tobacco workers due to excess cases among bakers and pastry cooks, food process workers and tobacco workers. An SMR of 127 was found for painters, due to excess cases among painters and decorators and coach painters.

An excess of 40 cases was found among transport and communication workers, of which 19 were among deck and engine room crew and 14 among railway workers. Analysis by industry showed elevated risk for six of the nine transport industries, including railways, sea transport and river transport. Other occupations with an excess of cases included chemical process workers, glass formers and finishers, machine tool operators and shoemakers and repairers.

A deficit of cases was found among administrators and managers and professional, technical and artistic workers.

Table III shows risk of bladder cancer associated with exposure to specific chemical agents. Elevated risk was

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Table I Observed deaths (Obs), expected deaths (Exp) and mortality ratios standardised for age and degree of urbanisation (SMR), according to occupation

Occupation	*Obs*	*Exp*	*SMR*	*95% CI*
Farmers, Foresters, Fishermen				
Fisherman	10	3.4[a]	296	142– 545
Farmer	13	22.1	59	32– 100
Farm worker	15	15.3	98	55– 162
Farm machinery driver	2	1.1	186	22– 672
Gardener, groundsman	18	17.1	106	62– 167
Forester	1	1.9	55	1– 305
	59	60.8	97	75– 125
Miners and quarrymen				
Coal – below ground	51	51.2	100	76– 131
Coal – above ground	8	10.5	76	33– 150
Other mining – below ground	0	0.8	0	0– 448
Other mining – above ground	1	2.1	48	1– 270
	60	64.6	93	72– 120
Gas, coke and chemical makers				
Coal, gas, furnaceman	0	3.8	0	0– 96
Labourer – coke oven, gas works	5	1.8	277	90– 645
Chemical process worker	49	34.3	143	106– 188
Labourer – chemical works	12	11.1	109	57– 192
	66	50.9	130	102– 165
Glass and ceramics makers				
Ceramic former	0	0.2	0	0–1788
Glass former, finisher	12	5.7	210	109– 368
Glass, ceramic furnaceman	0	3.1	0	0– 117
Ceramic finisher, decorator	0	0.0	–	
Glass, ceramic process worker	1	1.4	74	2– 411
Labourer – glass, ceramics	1	5.6	18	0– 99
	14	16.1	87	48– 147
Furnace, forge, foundry, rolling mill workers				
Metal furnaceman	7	5.1	138	55– 284
Rolling tube mill operator	1	4.2	24	1– 134
Foundry moulder, coremaker	9	5.2	172	79– 327
Smith, forgeman	6	7.6	79	29– 171
Metal worker n.e.c.	2	0.5	372	45–1342
Fettler, metal dresser	1	4.3	24	1– 131
Labourer – foundry works	6	5.2	115	42– 252
	32	32.1	100	71– 141
Electrical and electronic workers				
Radio, radar mechanic	5	2.9	170	55– 397
Telephone installer, repairer	14	9.5	148	81– 248
Linesman, cable jointer	5	2.7	185	60– 430
Electrician	36	27.1	133	93– 183
Electrical fitter	4	3.4	118	32– 304
Electrical assembler	0	1.9	0	0– 194
Electrical engineer	11	2.7	409	204– 732
	75	50.2	149	119– 187
Engineering and allied trades workers				
Foreman – engineering	9	8.5	106	48– 201
Sheet metal worker	9	8.1	112	51– 212
Steel erector	9	11.1	81	37– 154
Plate worker, riveter	30	16.7	180	121– 257
Welder	12	16.3	74	38– 129
Turner	5	3.2	154	50– 360
Machine tool setter	9	10.7	84	38– 160
Machine tool operator	36	22.3	162	113– 223
Tool maker	4	5.4	74	20– 188
Mechanic	7	11.9	59	24– 121
Maintenance fitter	31	32.1	97	66– 137
Fitter	54	53.0	102	78– 133
Electro-plater	1	2.5	40	1– 222
Plumber, gas fitter	23	15.4	149	95– 224
Pipe fitter	7	10.2	69	28– 141
Press worker	1	2.3	44	1– 246
Metal worker n.e.c.	6	9.6	63	23– 136
Watch maker and repairer	3	0.8	386	79–1126
Precision instrument maker	2	4.5	44	5– 161
Goldsmith	0	0.7	0	0– 519
Coach builder	3	3.9	78	16– 227
Inspector – metal	14	22.9	61	33– 103
Other metal worker	50	43.8	114	85– 151
Labourer – engineering works	49	56.7	86	64– 114
	374	372.6	100	91– 111
Woodworkers				
Carpenter, joiner	42	43.0	98	70– 132
Cabinet maker	3	2.9	102	21– 297
Wood machinist	8	9.9	81	35– 160
Pattern maker	1	1.5	68	2– 381
Woodworker n.e.c.	5	5.3	94	30– 218
	59	62.6	94	73– 122

continued overleaf

Table I – *(continued)*

Occupation	*Obs*	*Exp*	*SMR*	*95% CI*
Leather workers				
Tanner	0	2.8	0	0– 130
Shoemaker, shoe repairer	8	1.8	447	193– 881
Footwear cutter	0	2.0	0	0– 184
Leather product maker	1	1.6	62	2– 345
	9	8.2	109	50– 207
Textile workers				
Fibre preparer	0	0.2	0	0–1499
Textile spinner	1	0.1	1074	27–5981
Textile winder	0	0.3	0	0–1358
Textile warper	0	0.0	–	
Weaver	0	1.1	0	0– 350
Knitter	0	0.1	0	0–3481
Bleacher, finisher	1	0.3	336	9–1874
Textile dyer	0	0.0	–	
Fabric maker, examiner	1	1.4	72	2– 402
Textile process worker	0	0.4	0	0– 922
Labourer – textile works	0	1.8	0	0– 209
	3	5.6	53	11– 156
Clothing workers				
Tailor	3	4.5	66	14– 194
Upholsterer	3	5.5	54	11– 159
Sewer	1	1.9	51	1– 286
Clothing maker n.e.c.	0	1.9	0	0– 196
	7	13.8	50	20– 104
Food, drink and tobacco workers				
Baker, pastry cook	15	9.4	159	89– 263
Butcher, meat cutter	10	18.6	54	26– 99
Brewer	0	1.5	0	0– 242
Food process worker n.e.c.	34	18.1	188	130– 263
Tobacco worker	5	0.7	694	225–1617
	64	48.3	132	104– 169
Paper and printing workers				
Paper and paperboard maker	7	3.4	203	82– 419
Paper product maker	1	5.3	19	0– 105
Compositor	6	3.5	171	63– 373
Print press operator	6	7.6	79	29– 171
Printer	7	5.3	132	53– 271
Printing worker n.e.c.	3	9.3	33	7– 95
	30	34.5	87	59– 124
Makers of other products				
Rubber worker	5	2.1	239	78– 558
Plastic worker	5	4.0	124	40– 289
Craftsman n.e.c.	2	3.7	54	7– 194
Other process worker	4	9.0	45	12– 114
	16	18.8	85	49– 138
Construction workers				
Bricklayer	18	24.9	73	43– 114
Mason	3	0.9	316	65– 924
Plasterer	4	4.9	81	22– 208
Builder	13	10.7	122	65– 208
Bricklayer's labourer	3	2.6	115	24– 336
Labourer – building	24	35.9	67	43– 99
Construction worker n.e.c.	47	41.6	113	83– 150
	112	121.5	92	77– 111
Painters				
Spray painter	3	3.2	92	19– 270
Painter, decorator	57	47.4	120	93– 156
Coach painter	5	0.7	703	228–1638
	65	51.3	127	99– 161
Drivers of stationary engines, cranes, etc				
Boilerman	11	16.3	68	34– 121
Crane, hoist operator	27	20.9	129	85– 188
Construction machine operator	10	6.1	164	79– 302
Plant operator	22	32.3	68	43– 103
	70	75.6	93	73– 117
Labourer N.E.C.	152	108.1	141	120– 165
Warehousemen, storekeepers, packers				
Warehouseman	97	92.3	105	86– 128
Packer	12	18.6	64	33– 113
	109	110.9	98	82– 118

continued opposite

Table I – (*continued*)

Occupation	*Obs*	*Exp*	*SMR*	*95% CI*
Transport and communication workers				
Ship's officer	7	5.4	130	52– 269
Deck and engine room crew	24	5.4	442	283– 654
Aircraft pilot	0	0.0	–	
Railway engine driver	13	8.1	161	85– 275
Railway shunter	4	2.7	149	40– 382
Railway signalman	5	3.4	146	47– 339
Railway guard	4	1.6	258	70– 661
Railway lengthman	11	7.5	147	73– 263
Driver – bus	14	17.3	81	44– 136
Driver – taxi	18	14.5	124	73– 196
Driver – truck	92	85.3	108	88– 132
Transport inspector	12	11.5	104	54– 182
Traffic controller	0	0.7	0	0– 535
Telephone operator	4	6.0	67	18– 171
Telegraph operator	1	1.7	59	2– 328
Postman, mail sorter	31	24.2	128	87– 182
Messenger	12	13.1	91	47– 160
Bus conductor	6	9.2	65	24– 142
Railway porter	12	10.7	112	58– 196
Dock labourer	34	35.9	95	66– 132
Truck drivers' mate	1	1.0	95	3– 531
Worker in transport n.e.c.	2	1.9	103	13– 373
	307	267.2	115	103– 128
Clerical workers				
Office manager	12	9.5	126	65– 221
Clerk	147	176.4	83	71– 98
Office machine operator	1	0.4	252	6–1402
Typist, secretary	1	1.2	84	2– 467
Civil service executive	18	8.0	224	133– 354
	179	195.5	92	79– 106
Sales workers				
Proprietor – sales	89	93.0	96	78– 118
Sales assistant	24	21.7	110	71– 164
Roundsman	5	3.8	132	43– 308
Street vendor	5	6.1	82	26– 191
Garage proprietor	3	1.1	269	56– 786
Commercial traveller	16	18.9	85	48– 137
Finance agent	3	1.8	169	35– 494
Sales agent	20	25.6	78	48– 120
	165	172.0	96	82– 112
Service, sport and recreational workers				
Fireman	3	3.8	79	16– 231
Policeman	1	5.5	18	0– 102
Guard	47	43.6	108	79– 143
Publican	14	12.2	114	62– 192
Barman	4	7.2	56	15– 143
Hotel manager	3	4.0	75	16– 220
Housekeeper	1	1.5	67	2– 373
Restaurateur	4	9.2	43	12– 111
Waiter	2	3.5	57	7– 206
Canteen assistant	1	1.6	64	2– 357
Cook	6	6.9	86	32– 189
Kitchen hand	2	3.7	54	7– 194
Valet	1	5.4	19	0– 104
Caretaker	20	22.1	90	55– 139
Cleaner	17	13.2	128	75– 205
Hairdresser	6	4.9	123	45– 268
Launderer	4	5.2	77	21– 198
Sportsman	0	0.7	0	0– 542
Hospital orderly	12	14.9	81	42– 141
Proprietor – sport	8	6.1	132	57– 260
Service worker n.e.c.	22	20.8	106	66– 160
	178	195.8	91	78– 105
Administrators and managers				
Minister of the Crown	7	5.2	134	54– 277
Local authority officer	6	9.4	64	23– 139
Manager – engineering	16	20.8	77	44– 125
Manager - building	6	11.8	51	19– 111
Manager – mining	15	17.1	88	49– 145
Personnel manager	4	4.2	96	26– 246
Sales manager	12	13.5	89	46– 155
Manager n.e.c.	37	42.8	86	61– 119
	103	124.8	83	68– 100

continued overleaf

Table I – (*continued*)

Occupation	*Obs*	*Exp*	*SMR*	*95% CI*
Professional, technical workers, artists				
Doctor	5	4.7	107	35– 250
Dentist	2	0.8	249	30– 898
Nurse	4	3.7	109	30– 278
Pharmacist	3	3.2	95	20– 277
Medical worker – n.e.c.	1	1.8	56	1– 310
Health inspector	0	1.5	0	0– 246
Teacher – university	1	2.3	44	1– 243
Teacher – school	13	18.7	70	37– 119
Teacher – n.e.c.	12	11.8	102	53– 178
Engineer – civil	5	4.3	116	38– 269
Engineer – mechanical	3	8.8	34	7– 100
Engineer – electrical	3	3.7	81	17– 236
Engineer – electronic	3	1.4	214	44– 624
Engineer – work study	3	0.8	390	80–1138
Engineer – planning	1	3.5	29	1– 160
Engineer – n.e.c.	4	0.9	436	119–1116
Metallurgist	0	0.0	–	
Technologist	1	3.4	29	1– 162
Chemist	5	2.6	189	61– 441
Scientist	0	0.9	0	0– 402
Author	3	4.4	68	14– 199
Actor	0	1.1	0	0– 330
Artist	1	1.1	87	2– 486
Accountant	7	4.3	163	65– 336
Company secretary	5	10.4	48	16– 112
Surveyor	3	4.7	63	13– 185
Architect	0	2.5	0	0– 148
Clergy	6	9.5	63	23– 138
Solicitor	1	3.4	30	1– 164
Social welfare worker	3	6.2	49	10– 142
Association official	2	1.0	197	24– 712
Professional worker n.e.c.	1	4.3	23	1– 129
Draughtsman	3	7.4	41	8– 119
Laboratory worker	5	9.4	53	17– 124
Technical worker n.e.c.	12	18.9	63	33– 111
	121	167.4	72	60– 86
Armed forces	3	2.6	115	24– 335

[a]Expected deaths rounded to nearest tenth. Abbreviations: n.e.c., not elsewhere classified.

associated with exposure to aromatic amines, benzene, cutting oils and paints and pigments.

Discussion

This study had several potential sources of bias. First, different data sources were used to estimate the numerator (death certificates) and denominator (census) of the SMR. Death certificates record usual occupation whereas the census collects information on current or more recent occupation. Problems of compatibility may occur for workers (e.g., itinerate workers and general labourers) who may work in a variety of jobs. Additionally, it has been noted (OPCS, 1978) that next of kin may promote the deceased from a low to a higher status occupation at death registration.

Reporting bias may have occurred if registrars were aware that a particular occupation had been associated with bladder cancer and this knowledge led to more precise details being recorded on some certificates. If information bias was present, it would only occur in cases from occupations and industries known, prior to 1980, to be associated with bladder cancer (e.g., chemical dyestuff industry, coke ovens and gas works). However, a deficit of cases occurred among these workers, suggesting that reporting bias was not a problem in this study. Associations first suggested after 1980 (e.g., diesel exhaust fumes) are unlikely to be influenced by reporting bias.

Information on occupation and industry were obtained from a single entry on the death certificates and thus were probably less precise than if collected by interview. The death certificate statement gives no clue to lifetime occupational history and the occupation recorded at death may not reflect exposures that occurred around 20 years before the onset of disease.

The study does however have a number of strengths. First, precision was maximised by pooling deaths over 16 years and by excluding cases aged 65 or older; younger persons were more likely to have an autopsy and thereby a more accurate diagnosis than older persons. Second, bias due to misclassification of occupation was minimised by only including persons of working age. Third, mortality ratios were standardised for both age and degree of urbanisation. The absence of data on the smoking habits of cases and the underlying population was partly circumvented by using degree of urbanisation as a proxy measure of smoking and other non-occupational factors. Adjusting for degree of urbanisation had little influence on risk estimates, other than slightly shifting the SMRs towards unity.

Transport workers

Increased risk was seen for all railway workers (SMR,222). The SMR for each railway-related occupation was elevated: railway engine drivers (SMR,161), shunters (SMR,149), guards (SMR,258) signalmen (SMR,146) and lengthmen (SMR,147). Six recent case-control studies have presented data on bladder cancer risk among railway workers, five of which reported risk estimates above 1.0 (Howe *et al.*, 1980; Silverman *et al.*, 1983; Veneis & Magnani, 1985; Brownson *et al.*, 1987; Claude *et al.*, 1988; Risch *et al.*, 1988). One cohort study of railway workers evaluated bladder cancer risk and

Table II Observed deaths (Obs), expected deaths (Exp) and mortality ratios standardised for age and degree of urbanisation (SMR), according to industry of employment

Industry	*Obs*	*Exp*	*SMR*	*95% CI*
Agriculture, forestry, fishing				
Farming, market gardening	30	33.4	90	61– 128
Forestry	2	0.7	286	35–1032
Fishing	10	5.0	200	96– 368
	42	39.2	107	77– 145
Mining and quarrying				
Coal mining	76	49.4	154	123– 193
Stone, slate quarrying	5	1.6	322	104– 750
Chalk, clay, sand, gravel	0	1.2	0	0– 297
Petroleum and natural gas	1	0.1	754	19–4202
Other mining	1	1.3	76	2– 424
	83	53.6	155	125– 192
Food, drink and tobacco				
Grain milling	7	4.5	157	63– 323
Bread and flour confectionary	21	10.8	194	120– 296
Biscuit making	3	3.0	98	20– 287
Bacon curing, meat, fish	1	7.7	13	0– 73
Milk and milk products	9	4.0	222	102– 422
Sugar	5	3.5	144	47– 334
Cocoa, chocolate confectionary	6	4.7	127	47– 278
Fruit and vegetables	0	2.8	0	0– 133
Animal and poultry foods	7	4.9	144	58– 296
Vegetable and animal oils and fat	9	3.5	256	117– 487
Food industries n.e.c.	4	6.4	62	17– 159
Brewing and malting	16	10.8	148	84– 239
Soft drinks	2	2.5	81	10– 293
Other drink industries	2	0.8	246	30– 889
Tobacco	10	4.4	227	109– 417
Inadequately described[a]	2			
	104	74.4	140	115– 169
Coal and petroleum products	9	13.8	65	30– 124
Chemical and allied industries				
General chemicals	53	42.7	124	95– 162
Pharmaceutical chemicals	2	7.5	27	3– 96
Toilet preparations	1	0.9	112	3– 622
Paint	10	3.8	264	126– 485
Soap and detergent	3	5.1	59	12– 171
Synthetic resins, plastics	1	11.1	9	0– 50
Dyestuffs and pigments	2	3.9	51	6– 186
Fertilisers	2	4.7	43	5– 155
Other chemical industries	5	4.6	110	36– 256
	79	84.2	94	75– 117
Metal manufacture				
Iron and steel	77	65.8	117	94– 146
Steel tubing	0	2.9	0	0– 128
Iron castings	6	4.0	149	55– 325
Aluminium	1	3.6	27	1– 152
Copper, brass, alloys	2	3.4	58	7– 210
Other base metals	3	5.7	53	11– 153
Inadequately described[a]	5			
	94	85.5	110	90– 134
All engineering industries	325	349.6	93	83– 104
Textiles	16	22.1	73	41– 117
Leather, leather goods and fur	5	4.6	108	35– 253
Clothing and footwear	11	15.6	71	35– 126
Brick, pottery, glass, cement, etc				
Bricks, refractory goods	4	4.3	93	25– 237
Pottery	0	1.9	0	0– 191
Glass	22	18.3	120	75– 181
Cement	8	4.9	162	70– 319
Abrasives, building materials	6	10.4	57	21– 125
	40	40.0	100	71– 136
Timber, furniture				
Timber	5	11.2	44	14– 104
Furniture, upholstery	10	10.1	99	47– 181
Bedding	0	1.2	0	0– 302
Shop, office fittings	3	4.3	70	14– 203
Wooden containers, baskets	2	2.0	101	12– 365
Miscellaneous wood products	1	4.7	21	1– 119
Inadequately described[a]	7			
	28	33.6	83	55– 121

continued overleaf

Table II – (*continued*)

Industry	*Obs*	*Exp*	*SMR*	*95% CI*
Paper manufacture				
Paper and paper board	17	14.9	114	66– 182
Packaging products	1	10.0	10	0– 56
Manufactured stationary	1	1.7	58	1– 322
Manufactured paper n.e.c.	1	2.3	43	1– 239
	20	29.0	69	42– 107
Printing and publishing				
– newspapers	15	12.6	120	67– 197
– periodicals	0	3.3	0	0– 112
– other	29	25.3	115	77– 165
	44	41.2	107	78– 143
Other manufacturing industries				
Rubber	8	7.0	115	49– 226
Linoleum, floor coverings	0	0.3	0	0–1123
Brushes, brooms	1	0.6	165	4– 920
Toys, games, sports equipment	0	2.6	0	0– 145
Misc. stationers' goods	3	0.8	393	81–1147
Plastic goods n.e.c.	8	6.7	119	51– 234
Misc. manufacturing industries	1	2.4	42	1– 234
	21	20.3	103	64– 158
Construction	205	225.2	91	79– 104
Gas, electricity and water				
Gas	16	15.6	103	59– 167
Electricity	35	26.3	133	93– 185
Water supply	10	4.8	209	100– 385
	61	46.6	131	102– 168
Transport and communication				
Railways	74	33.3	222	177– 279
Road passenger transport	38	37.1	102	72– 140
Road haulage contracting	32	40.9	78	53– 110
Other road haulage	0	1.4	0	0– 267
Sea transport	27	17.2	157	103– 229
Port and river transport	62	45.0	138	107– 176
Air transport	0	2.2	0	0– 171
Postal services, telephones	63	47.2	134	104– 171
Misc. transport services	21	18.8	111	69– 170
Inadequately described[a]	1			
	318	243.2	131	117– 146
Distribution trades				
Wholesale food, drink	18	25.2	71	42– 113
Wholesale petroleum	3	6.7	45	9– 130
Other wholesale distribution	10	20.6	49	23– 89
Retail food, drink	51	47.8	107	81– 140
Other retail distribution	72	74.7	96	76– 121
Dealing in coal, oil, etc	13	14.4	90	48– 155
Dealing in other materials	13	17.7	74	39– 126
Inadequately described[a]	7			
	187	207.2	90	78– 104
Insurance, banking, finance				
Insurance	20	24.0	83	51– 128
Banking	13	19.1	68	36– 117
Other financial institutions	1	7.0	14	0– 79
Property owning, managing	4	5.2	77	21– 197
Advertising, market research	2	2.7	73	9– 264
Other business services	4	8.9	45	12– 115
Offices n.e.c.	0	0.8	0	0– 492
	44	67.7	65	47– 87
Professional and scientific services				
Accountancy services	0	7.2	0	0– 51
Schools, universities	38	54.6	70	49– 95
Legal services	5	5.9	85	28– 198
Medical, hospital services	36	35.7	101	71– 139
Religious organisations	7	5.2	136	54– 280
Research and development	0	4.1	0	0– 90
Other professional services	4	14.4	28	8– 71
	90	127.0	71	58– 87

continued opposite

Table II – (*continued*)

Industry	*Obs*	*Exp*	*SMR*	*95% CI*
Miscellaneous services				
Cinema, theatre, radio	5	8.5	59	19– 138
Sport, recreation	8	4.6	174	75– 343
Betting, gambling	2	6.6	30	4– 109
Hotels	12	10.1	118	61– 207
Restaurants, cafes	8	10.0	80	35– 158
Public houses	16	7.2	221	126– 358
Clubs	3	4.0	75	15– 218
Catering contractors	3	2.4	123	25– 360
Hairdressers	6	4.4	137	50– 298
Domestic services	4	2.0	203	55– 520
Laundries	1	3.0	33	1– 185
Dry cleaning, job dying	1	1.2	83	2– 462
Motor repairs, sales, garages	24	47.3	51	33– 75
Boot, shoe repair	7	1.1	640	257–1319
Funeral services	3	1.2	246	51– 719
Photography	2	1.9	108	13– 388
Welfare, charitable services	2	5.1	39	5– 143
Community services	2	1.3	157	19– 568
Foreign government services	2	0.9	228	28– 825
Trade association	1	2.1	47	1– 262
Other services	7	8.2	85	34– 176
	119	133.0	89	75– 107
Public administration, defence				
Armed forces, defence	16	24.6	65	37– 106
Government services	44	32.1	137	100– 184
Police	3	16.2	19	4– 54
Fire	2	4.4	46	6– 166
Local government services	79	61.4	129	103– 160
	144	138.6	104	88– 122

[a]Industry able to be coded to correct order, but insufficient information to code to correct industrial unit.

Table III Observed deaths (Obs), expected deaths (Exp) and mortality ratios standardised for age and degree of urbanisation (SMR), according to degree of exposure

	Occupations in which most workers had some exposure to agent				*Most workers low exposure only*				*Most workers high exposure only*			
Exposure	*Obs*	*Exp*	*SMR*	*95% CI*	*Obs*	*Exp*	*SMR*	*95% CI*	*Obs*	*Exp*	*SMR*	*95% CI*
Aromatic amines	145	120.7	120	101–141	120	97.3	123	102–147	25	23.1	108	70–160
Benzene	64	57.6	111	86–142	20	26.6	75	46–116	44	31.0	142	103–191
Chromium/chromates	82	78.7	104	83–129	73	71.3	102	80–129	9	7.4	122	56–231
Cutting oils	54	41.6	130	98–169	–[a]	–	–		54	41.6	130	98–169
Diesel fuel/fumes	125	118.1	106	88–126	125	118.1	106	88–126	–[a]	–	–	
Dyestuffs	19	19.8	96	58–150	17	15.9	107	62–171	2	3.9	51	6–185
Organic solvents	175	171.5	102	87–118	75	85.7	88	69–110	100	85.8	117	95–142
Paints, pigments	75	55.1	136	107–171	–[a]	–	–		75	55.1	136	107–171
P.A.H.'s	137	131.6	104	87–123	26	27.6	94	62–138	111	104.0	107	88–129
Soot, tar, mineral oil	142	122.3	116	98–137	58	52.5	110	84–143	84	69.8	120	96–149

[a]No occupations in this category.

found a relative risk of 1.0 (Howe *et al.*, 1983). Railway workers may be exposed to a range of substances in their workplace. Most engine drivers would have been exposed to coal dust, polycyclic aromatic hydrocarbons, soot and tar. It is not clear what chemical agents other railway workers would have been exposed to.

An association was found with the sea transport industry (SMR,157) and the port and river transport industries (SMR, 138). Analysis by occupation revealed an excess of deaths among deck and engine room crew (SMR,442), an occupational unit which includes merchant seamen, barge operators and boatmen. Increased risk was also found among ship's officers (SMR,130), but a slight deficit of cases occurred among dock labourers (SMR,95). Four case-control studies have reported on bladder cancer for sailors and the shipping industry, three of which found reduced risk (Lockwood, 1961; Dunham *et al.*, 1968; Silverman *et al.*, 1983; Jensen *et al.*, 1987). Kelman and Kavaler (1990) studied disease patterns in merchant seamen and suggested that seamen tend to be heavy cigarette smokers, consume more than average quantities of alcohol and work in shipboard environments characterised by the inhalation of gas and oil exhaust fumes. The crew of ships may also be exposed to solvents, metal-based anti-rust paints and creosote.

Exposure to diesel exhaust

The job-exposure matrix identified four occupations in which the majority of workers were exposed (but only low exposure) to diesel fuel or diesel fumes: truck, bus and taxi drivers and truck drivers' mates. The combined SMR for these occupations was 106. SMRs above 100 were seen for truck and taxi drivers but not for bus drivers. Thus, this study provides limited support for an association between bladder cancer and exposure to diesel exhaust.

Electrical and electronic workers

An excess of cases occurred among electrical and electronic workers. Specific occupational groups with elevated risk included electrical engineers, electricians, telephone installers and repairers, and telephone linesmen and cable jointer. It has been suggested that electrical workers are promoted by next of kin to the more prestigious title of electrical engineer at death registration (OPCS, 1978). This may account for the elevated SMR among electrical engineers being substantially higher than the SMRs for other electrical workers, but does not account for the overall excess of cases for all electrical and electronic workers.

There is limited epidemiological evidence of a risk among electrical and electronic workers. Seven case-control studies and one registry-linkage study have examined bladder cancer risk among electrical and electronic workers, of which four found at least a 20% excess of cases (Anthony & Thomas, 1970; Silverman *et al.*, 1983; Baxter & McDowall, 1986; Coggon *et al.*, 1986; Malker *et al.*, 1987; Claude *et al.*, 1988; Gonzalez *et al.*, 1989; Schumacher *et al.*, 1989).

Steineck *et al.* (1989) reported elevated risk for exposure to polychlorinated biphenyls (PCB). PCBs have until recently been widely used as coolants in electrical transformers. In the current study, no single occupational or industrial group was identified in which most workers had exposure to PCBs. However, some workers in the electrical machinery, insulated cable manufacturing and electricity industries probably had high exposure to PCBs. An excess of cases occurred among electricity industry workers (SMR,133; 95% CI, 93–185) but a deficit occurred among electrical machinery and insulated cable manufacturing workers (SMR,36; 95% CI, 16–71), although the later probably underestimates the true risk because insufficient information was available for many engineering and manufacturing workers to be assigned to an exact industry. Some radio and radar mechanics, telephone installers and repairers, electrical fitters and electrical assemblers probably had low exposure to PCBs. The summary SMR for these occupations was 130 (95% CI, 82–195).

Shoemakers and repairers

Eight deaths occurred among shoemakers and repairers whereas less than two were expected. Misclassification of other leather workers (obs,1; exp, 6.4) as shoemakers or repairers may explain the observed excess. Seven case-control studies and one cohort study have evaluated bladder cancer risk among shoemakers and repairers, six of which reported risk estimates above 1.0 (Wynder *et al.*, 1963; Schoenberg *et al.*, 1984; Vineis & Magnani, 1985; Baxter & McDowall, 1986; Walrath *et al.*, 1987; Claude *et al.*, 1988; Bonassi *et al.*, 1989; Silverman *et al.*, 1989). The agent responsible for the risk is unknown. Shoemakers and repairs may have been exposed to a range of agents including leather dust, dyes, adhesives and polishes.

Food industry workers

In this study, an excess of cases was found among bakers and pastry cooks and food process workers, and in the following food industries: bread and flour confectionary, milk and milk products and extraction of vegetable and animal oils and fats. There is little epidemiological support for our finding of increased risk among bakers, pastry cooks and other workers in the bread and confectionary industry. One cohort study (Carstenssen *et al.*, 1988), three case-control studies (Silverman *et al.*, 1983; Veneis & Magnani, 1985; Claude *et al.*, 1988) and one registry linkage study (Malker *et al.*, 1987) have reported on bladder cancer among bread and confectionary workers and each found no evidence of elevated risk.

Nine deaths occurred among milk industry workers, whereas 4.0 were expected. Included in this category were workers employed in establishments undertaking milk processing and pasteurising and the making of butter, cheese and ice cream. The risk of bladder cancer among workers in the milk industry has not been evaluated in previous studies.

Nine deaths occurred amongst employees of establishments involved in the extraction of vegetable and animal oils and fats. Coggon (1986) in a case-control study of bladder cancer incidence in the north of England also found an excess of cases among men employed in the production of vegetable and animals oils and fats. The nine cases observed in the present study are different cases from those reported by Coggon.

A further two cases employed in the oils and fats extraction industry were identified but excluded from these analyses: one died from sarcoma of the bladder, the other had dual primary sites (bladder and breast) with death being attributed to breast cancer. It is possible that bladder cancer risk resulted from exposure to one of the solvents used to extract the oils and fats.

Tobacco industry

Excess mortality among employees of the tobacco industry (SMR,227) agrees with the two- to four-fold increase in risk of bladder cancer due to smoking cigarette reported in other studies (Dolin, 1991). However, a far stronger risk was seen for those workers specifically involved in tobacco manufacture (SMR, 694). These findings suggest that workers involved in tobacco manufacture are at particularly high risk of bladder cancer, higher than could be accounted from by smoking alone, and that occupational exposure to tobacco during its processing must entail some carcinogenic risk.

Fishermen

An elevated risk was seen for fishermen (SMR,296). Few studies have evaluated the bladder cancer risk among fishermen. Neutel (1989) studied a cohort of 33,000 commercial fishermen in Canada and found 22 deaths from bladder cancer during 8 years of follow-up (SMR,121; 95% CI, 76–183). The findings of most relevant case-control studies are difficult to interpret because fishermen are usually grouped with agricultural and forestry workers. The fishermen in the current study were deep sea fishermen rather than inland fishermen and may have been exposed to marine paints, creosote and possibly to diesel exhaust fumes.

Glass workers

An excess of cases occurred among glass formers and finishers but not among other glass workers. This may reflect misclassification or promotion by next of kin of the other glass workers (obs,2; exp,10.3) to the higher status occupation of glass formers and finishers (obs,12; exp,5.7). Previous studies provide inconsistent evidence for an association. Three studies have reported an excess of bladder cancer among glass workers with relative risk ranging from 3.8 to 6.0 (Howe *et al.*, 1980; Silverman *et al.*, 1983; Coggon *et al.*, 1986) while three others have found no association (Anthony & Thomas, 1970; Malker *et al.*, 1987; Gonzalez *et al.*, 1989).

Exposure to dyestuffs

The job-exposure matrix identified five occupational groups in which most workers were likely to have been exposed to dyestuffs. For two groups (dyestuff and pigment manufacturing workers and textile dyers) most workers were likely to have had high exposure (SMR,51), while in the remainder (paper and paperboard manufacturing, textile finishing and linoleum and plastic floor covering manufacturing workers) most had low exposure (SMR,107). This suggests that little risk is associated with exposure to dyestuffs and is consistent with Case *et al.* (1954) who demonstrated that carcinogenic risk among dyestuff workers resulted from exposure to aromatic amines during the manufacture of dyestuffs rather than from exposure to the dyestuffs themselves.

Exposure to aromatic amines

A 20% excess of cases were employed in occupations in which most workers were likely to have been exposed to aromatic amines. Most of the excess (SMR,123) occurred in occupational groups in which most workers had low exposure to aromatic amines (painters and decorators, paper makers, linoleum and plastic floor covering manufacture, photography workers, compositors, radiographers, turners, tool setters, tool operators and tool makers), where as little excess (SMR,108) occurred in occupational groups in which most workers had high exposure to aromatic amines (printers, printing press workers, rubber workers, textile dyers, textile finishing, tanners, dyestuff manufacture and coach painters). The small risk for the high exposure group may reflect improvements in working conditions in industries where high exposure to aromatic amines has traditionally occurred.

Exposure to paints and pigments

The summary SMR for high exposure to paints and pigments was 136 (95% CI, 107–171) based on four occupations in which most workers were likely to have been exposed: painters and decorators, coach painters (mainly railway coach painters), spray painters and paint manufacturing workers. A consistent excess of bladder cancer among painters has been shown in two large cohort studies and collections of national mortality statistics, plus 15 case-control studies have examined bladder cancer in relation to exposure to paint, eight of which have shown an excess in all painters (IARC, 1989). The recent review of occupational bladder cancer by the British Association of Urological Surgeons (BAUS, 1988) makes no mention of risk among painters. The present findings together with supporting epidemiological evidence suggests that this group of workers may be at particular risk of bladder cancer. Painters may also have been exposed to a wide range of other substances including solvents, metal-based paints and chromium compounds. Coach and spray painters and paint manufacturing workers may also have had high exposure to benzene.

Exposure to cutting oils

Four occupational groups (turners, machine tool setters, machine tool operators and tool makers) had high exposure to cutting oils, the summary SMR was 130 (95% CI, 98–169). Elevated risk has been reported in most studies of machinists reviewed by IARC (1984) and Steineck *et al.* (1990). It has been suggested that excess risk among these workers may result from exposure to cutting oils containing aromatic amine additives (IARC, 1984).

Exposure to benzene

A summary SMR of 142 (95% CI, 103–191) was found for occupations in which most workers had high exposure to benzene. Included in this category were compositors, printers, printing press operators, spray painters, coach painters, paint manufacture, dyestuff manufacture, rubber workers, textile finishing and manufacture of waterproof outerwear. The summary risk estimate may be confounded because some of these occupational groups also had high exposure to aromatic amines.

Exposure to polycyclic aromatic hydrocarbons

No increase in risk was found for exposure to PAHs. Occupational groups with high exposure to PAHs include furnacemen and labourers at coke ovens and gas works, furnacemen and other workers in foundries and metal rolling mills, and chimney sweeps. In the present study, none of the cases worked as chimney sweeps and less than 0.1 case was expected. Doll *et al.* (1972) reported an excess of bladder cancer among coke oven and gas workers in England and Wales. In the present study, five cases worked as labourers in coke ovens and gas works, whereas only 1.8 were expected. However, this excess may have resulted from misclassification of coke oven furnacemen (obs,0; exp,3.8) as labourers.

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Appendix I Administrative districts of England and Wales included in the study

Cumbria coast	Humberside
Allerdale	Beverley
Barrow in Furness	Boothferry
Copeland	Cleethorpe
	Doncaster
Merseyside	
Alyn & Deeside	East Yorkshire
Delyn	Glandford
Ellesmere Port	Grimsby
Halton	Holderness
Knowsley	Kingston upon Hull
Liverpool	Scunthorpe
Rhuddlan	Selby
Sefton	
St Helens	London and Thames
Wirral	estuary
Wrexham	Barking
	Basildon
Tyneside and Teeside	Castle Point
Durham	Dartford
Easington	Gillingham
Hartlepool	Gravesham
Langborough	Havering
Middlesborough	Lambeth
Scarborough	Lewisham
South Tyneside	Newham
Stockton on Tees	Rochester
Sunderland	Southend
	Southwork
Severn estuary	Swale
Bristol	Thurrock
Cardiff	Tower Hamlets
Newport	Wandsworth
Northavon	
Sedgemoor	
Taff-ely	
Woodspring	
Vale of Glamorgan	