Occupations of fathers of children dying from neoplasms

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SUMMARY It has been suggested in a number of recent reports that there is a possible relationship between parental occupation and malignant disease in children. A proportional mortality analysis relating deaths among children in England and Wales in 1959–63 and 1970–72 to occupation of father as stated on the child's death certificate has not shown any convincing evidence for such associations. Earlier papers published on the subject are reviewed. Although there is some slight evidence for associations between childhood tumours and certain parental occupations there is little consistency between the results reported by different authors. A previously reported association between higher social class and deaths from neoplasms was found also in this study. The explanation for this finding is unknown, and it remains possible that it is an artefact.

Little is known about the causes of malignant disease in children although various studies have suggested that prenatal factors are responsible for some cases. Those factors include antenatal maternal x rays,¹ transplacental drug effects,² and maternal virus infections during pregnancy,^{3,4} though the evidence for this is less convincing and contradictory results have been found in different studies. Some cases are associated with chromosome defects⁵ and some with genetic disease.⁶

In several reports the occurrence of childhood cancer has been considered in relation to parental occupation; these include four case-control studies, one from Canada,⁷ one from Finland,^{8,9} and two from the United States of America.^{10,11}

Fabia and Thuy⁷ suggested that children of fathers in 'hydrocarbon-related occupations' might have an increased risk of malignant disease. In their study, 386 children under 5 dying of malignant disease were each matched with two controls born at about the same time, and the fathers' occupations, as recorded on birth certificates, were compared. Children born to fathers in 'hydrocarbon-related' occupations (defined as motor vehicle mechanics and service station attendants, machinists, miners and lumbermen, painters, dyers and cleaners) had approximately twice the risk of children of fathers in other occupations. The rationale for grouping occupations in this way is not clear from this paper, and in view of the rather mixed nature of the hydrocarbon-related group and the lack of specificity

in the causes of death, it seems the findings may well have been due to chance.

Hakulinen *et al*⁸ carried out a study of 852 children from the Finnish Cancer Registry. Each was matched with a control for date of birth and domicile. Fathers' occupations, as recorded when the mother first attended an antenatal centre, were analysed. No excess risk of cancer was found among children whose fathers were in hydrocarbon-related occupations. Hemminki *et al*⁹ reanalysed these data together with a further 700 cases also from Finland. This analysis covered children diagnosed with cancer in Finland in two periods, 1959–68 and 1969–75. A number of apparently increased risks were reported from various parental occupations.

The results reported included a small increased risk for children of fathers who were farmers and a relative risk of 1.9 for leukaemia in the period 1969–75 for children of fathers who were motor vehicle drivers. Increased risks were also reported for certain maternal occupations recorded at the time of pregnancy. However, in this study a large number of occupations were analysed, so that some statistically significant results would be expected to occur by chance.

Zack *et al*¹⁰ recorded parental occupations for 296 children with cancer attending the Texas Children's Hospital and compared these with occupations of (a) parents of patients without cancer, (b) siblings of the case parents, and (c) neighbours of the case parents. Information on job histories was collected

for the period from a year before birth to a year before diagnosis. No association between hydrocarbon-related occupations and childhood neoplasms was found for either fathers or mothers.

In a study based on data from the Connecticut tumour registry Kantor *et al.*¹¹ reported an association between Wilms's tumour—a renal tumour of childhood—and paternal occupations 'related to lead'. Controls for 149 children with Wilms's tumour were matched for sex, race, and year of birth. The paternal occupations were obtained from children's birth certificates. Fathers classified as being in 'lead-related' occupations were drivers, motor vehicle mechanics, service station attendants, welders, solderers, metallurgists, and scrap metal workers: thus there is considerable overlap with the definition of 'hydrocarbon-related' occupations. However, it is important to notice that in Fabia and Thuy's paper⁷ none of the 71 tumours reported among children of fathers in hydrocarbon-related occupations was a Wilms's tumour, although 25 (6.5%) of their total of 386 cases had this diagnosis. Nor was there any association between hydrocarbon-related occupations and Wilms's tumour in the report by Zack *et al.*¹⁰

There have also been two cohort studies of anaesthetists in which it has been suggested that their children may have an increased risk of developing cancer: Corbett *et al.*¹² reported three tumours (one at age 22) in two children out of 434 born to women anaesthetists; Tomlin¹³ reported tumours, at unspecified ages, in two children out of 276 whose fathers were anaesthetists. These numbers are greater than would be expected in the general population, but the published reports do not give sufficient information for the statistical significance of their findings to be assessed. It should be noted that the extent of the possible increase in risk is greatly exaggerated in the analysis presented in Tomlin's paper because the method of analysis used is incorrect—the effect being to multiply the estimated relative risk by an unknown factor which may well be 10 or more.

There appear to be no other published epidemiological studies on the relationship between parental occupation and childhood neoplasms.

We report in this paper an analysis of fathers' occupations, as recorded on death certificates, for all children dying in England and Wales during the years 1959–63 and 1970–72; the occupations of fathers of children dying from neoplasms are compared with those of children dying from other causes.

Method

For deaths among children under 15 in England and Wales the occupation of the father is routinely

recorded on the child's death certificate. For all deaths in these countries occurring during the years 1959–63 and 1970–72 occupations were coded according to the United Kingdom Standard Classification of Occupations^{14,15} for use in the analyses of occupational mortality produced by the Registrar General. For children, the father's occupation was coded; these data were made available for the present analysis.

There are no population data giving numbers of children having fathers in each occupational group, so it is not possible to calculate childhood death rates related to father's occupation; instead we have used proportional mortality ratios (PMRs). The PMR for a specified cause of death and occupational group is defined in the present study as:

$$100 \times \frac{\text{Proportion of deaths attributed to specified cause among children of fathers in the specified occupation}}{\text{Proportion of all childhood deaths attributed to the specified cause}}$$

Symbolically, if the total number of childhood deaths is T, and C of these are attributed to a specified cause, while the number of deaths among children with fathers in a given occupational group is t, with c being attributed to the specified cause,

$$\begin{aligned} \text{PMR} &= 100 \times \frac{c}{t} \div \frac{C}{T} \\ &= \frac{100cT}{tC} \end{aligned}$$

An association between the specified cause of death and paternal occupation will be reflected in a PMR greater than 100. This can be tested for statistical significance by means of a χ^2 test applied to the 2×2 table whose cell entries are c, t – c, C – c, (T – C) – (t – c).

A positive association between a particular cause of death and an occupational group may be evidence of a causal relationship resulting from occupational exposure to some carcinogenic or mutagenic agent; on the other hand, as with any statistical relationship, the association may be indirect, and not causal, or it may simply be due to chance. In an analysis of PMRs there is an important potential source of false inferences which we have considered particularly carefully in the present analysis: since the method consists in calculating the proportions of fathers in a specified occupational group for certain causes of death, and comparing this with the proportion in that group for all causes of death, a spurious association could arise if there were an association between some of the remaining causes of death and some of the

other occupations. In the particular case considered here, it is known that some non-neoplastic causes of childhood death are associated with lower social class and hence with certain parental occupations. In the analyses presented below we have therefore calculated PMRs by comparing numbers of deaths from neoplasms firstly with numbers of deaths from all causes and secondly with deaths from all causes excluding 'social-class-related' causes.

The data consisted of numbers of childhood deaths under the age of 15 for each paternal occupation category. Deaths from neoplasms were subdivided into four groups, leukaemias, brain tumours, kidney tumours, other neoplasms. For the 1959-63 data only, the numbers of deaths from other causes were also subdivided according to the main headings of the *International Classification of Diseases* and by the child's age at death.

Results

In Table 1 we give PMRs for childhood deaths attributable to neoplasms for fathers within each broad occupation order defined in the Registrar General's classifications of occupations.^{14 15} Most of the PMRs are fairly close to 100 and few of the figures show consistent deviations for the two periods. There are only three occupation orders, 22,

24, and 25 for which the PMRs were significantly high at the 5% level for each of the two periods. The PMRs for orders 3 and 21 were significant for the first period only. For reasons given below some at least of these findings may well be artefacts, and should not be taken as evidence of a direct association between these occupations and childhood cancer. The two most strikingly high PMRs are those for orders 24 and 25, which consist mainly of occupations in Social Classes I and II. Some causes of death are known to be less common for children in these social classes and this could account, at least in part, for the high PMR for neoplasms. The converse argument could be applied, for instance, to the low value for occupation order 18 (labourers).

The occupation orders in Table 1 are of course heterogeneous, and even if the individual occupation units within each order are considered, it is not possible to produce sharply defined groups which can be classified as 'hydrocarbon-related'. In consultation with a specialist in occupational health, we have defined a group which includes miners, various workers in the engineering and allied trades, some textile workers, printing press operators, painters and decorators, dry cleaners and motor vehicle drivers. This is considered to be as close an approximation as is possible, within the Registrar General's classification of occupations, to a group of

Table 1 Proportional mortality ratios for deaths from neoplasms among children of fathers in each occupation order

Father's occupation order*	1959-1963			1970-1972		
	Deaths from neoplasms	All deaths	PMR	Deaths from neoplasms	All deaths	PMR
1 Farmers	188	4 420	109	86	1 540	121
2 Miners	168	4 611	94	41	830	107
3 Gas, coke and chemical	58	1 045	143	21	525	87
4 Glass and ceramics	21	531	102	9	200	98
5 Furnace workers	72	1 709	108	36	697	112
6 Electrical	120	3 243	95	89	1 808	107
7 Engineering and allied trades	656	16 119	104	391	8 828	96
8 Woodworkers	104	2 772	96	56	1 293	94
9 Leather workers	15	442	87	5	153	71
10 Textile workers	38	1 039	94	25	722	75
11 Clothing workers	15	475	81	11	397	60
12 Food, drink and tobacco	79	1 686	120	35	850	89
13 Paper workers	54	1 167	119	29	636	99
14 Other products	54	1 180	117	29	695	91
15 Construction	171	4 379	100	107	2 462	94
16 Painters and decorators	93	2 472	97	34	1 002	74
17 Drivers of stationary engines, cranes, etc.	92	2 216	107	40	1 036	84
18 Labourers N.E.C.	304	11 714	67	176	5 066	75
19 Transport workers	429	11 904	93	252	5 166	106
20 Warehousemen	100	2 392	107	43	1 257	74
21 Clerical workers	252	4 375	148	124	2 388	113
22 Sales workers	340	6 633	132	199	3 411	127
23 Service, sport and recreation	177	3 977	114	115	2 480	101
24 Administrators and managers	162	2 295	181	140	1 859	163
25 Professional, technical workers, artists	393	7 139	141	294	4 671	137
26 Armed forces	126	4 469	72	61	1 544	86
27 Inadequately described, non-employed and others	114	8 436	35	77	3 290	51
TOTAL	4395	112 840	100	2 525	54 806	100

*Classifications of occupations^{14 15}

workers with particularly high exposure to hydrocarbons (HCR group). We have used this to test the hypothesis suggested by Fabia and Thuy.

In Table 2 we give the PMRs for this group in the two periods under consideration; these are close to 100 and there is no suggestion here of any association with mortality from neoplasms. In order to compare the HCR group with a group more similar in social class composition we have also calculated PMRs using as a comparison group all other occupations excluding orders 24 and 25. The PMRs resulting from this comparison are again very close to 100.

In Table 3 we show the PMRs for separate diagnostic categories of neoplasm. It will be observed that in each period the PMR for deaths from kidney tumours was higher than that for all other neoplasms, though in neither period was it significantly different from 100. These raised PMRs are nevertheless of interest when we consider the findings of Kantor *et al*¹¹ concerning 'lead-related' occupations. It is not possible within the Registrar General's classification of occupations to isolate a group of workers with particularly high exposure to lead but there is a

considerable overlap with those occupations defined as 'hydrocarbon-related'. Within this latter group, the particularly high PMRs for deaths from kidney tumours were concentrated among the children of workers in 'engineering and allied trades'.

The calculation of PMRs for one cause of death can be misleading if death rates from other causes differ as between the groups of individuals being compared. For the 1959-63 data for which the information on causes of death for each occupation unit was available to us, we have therefore calculated PMRs after excluding 'social class-related' causes of death. These are defined here as infective, respiratory, diseases of early infancy and accidents. Table 4 gives the resulting PMRs for each age group and for all ages together.

These analyses do not suggest any association between deaths from neoplasms and HCR occupations either for the total group of cases or for separate age groups.

We have already commented on the high PMRs for occupation orders 24 and 25; a detailed analysis for these groups combined is presented in Table 5. For

Table 2 Proportional mortality ratios for deaths from neoplasms among children of fathers in hydrocarbon-related occupations

Occupations	Deaths in 1959-63			Deaths in 1970-72		
	Neoplasms	All causes	PMR	Neoplasms	All causes	PMR
Hydrocarbon-related	1041	27 784	96	523	12 040	94
All	4395	112 840	100	2525	54 806	100

Table 3 Proportional mortality ratios for deaths from specified types of neoplasm among children of fathers in hydrocarbon-related occupations

Occupations	Kidney		Brain		Leukaemia		Other neoplasms		All deaths
	Deaths	PMR	Deaths	PMR	Deaths	PMR	Deaths	PMR	
1959-63									
Hydrocarbon-related	79	119	260	91	416	95	286	97	27 784
All	270	—	1161	—	1771	—	1193	—	112 840
1970-72									
Hydrocarbon-related	32	114	159	95	202	92	130	93	12 040
All	128	—	760	—	1000	—	637	—	54 806

Table 4 Proportional mortality ratios for deaths from neoplasms at specified ages among children of fathers in hydrocarbon-related occupations (deaths in 1959-63 only)

Occupations	Age groups (years)														
	0			1-4			5-9			10-14			All ages		
	Neo-plasm deaths	*All deaths	PMR	Neo-plasm deaths	*All deaths	PMR	Neo-plasm deaths	*All deaths	PMR	Neo-plasm deaths	*All deaths	PMR	Neo-plasm deaths	*All deaths	PMR
Hydrocarbon-related	95	6 094	93	382	1521	95	315	784	101	249	728	97	1041	9 127	96
All	412	24 697	100	1569	5993	100	1305	3290	100	1109	3144	100	4395	37 124	100

*Excluding deaths from social class-related causes.

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deaths in each period, and excluding those due to social class-related causes, the PMRs are given for separate diagnostic categories of neoplasm: for all of these the PMR is substantially greater than 100. The PMRs for 'all neoplasms' are statistically very highly significant ($p < 0.001$) in each period.

Social class differences in mortality from childhood neoplasms have been reported by Adelstein and White,¹⁶ who used the data for 1959-63 reported here, and made a direct calculation of actual mortality rates for deaths at the ages of 1-14.

Discussion

The results presented above are largely negative but two findings are possibly of some interest in the light of previous reports.

Firstly, the apparent association between kidney tumours and 'hydrocarbon-related occupations' is in line with the findings of Kantor *et al*¹¹ concerning Wilms's tumour and 'lead-related' occupations, and is biologically plausible, though it has not been confirmed in any other study.

Secondly, the apparently increased risk of cancer among children of parents in higher social classes has been previously reported. This may indicate a real difference in tumour incidence which is social class-related, but there is no obvious aetiological explanation (and other explanations are possible). Children in lower social classes may be more liable, when in a preclinical phase of cancer or leukaemia, to die from some other cause. Stewart and Kneale¹⁷ suggest an association between infection hazards and preleukaemia: lower incidence of infection and better medical care in the higher social classes would lessen the chance of dying from pneumonia or other infections. It is also possible that neoplasms are more likely to be misdiagnosed among children in lower

social classes. Thus, even if the true incidence of neoplasms was equal in different social classes, the number of children diagnosed and dying from these causes might be fewer in lower social classes. Alternatively, the apparent excess of deaths from neoplasms among higher social classes may be attributable to a relative deficit of deaths from other causes even when the specified 'social class-related' deaths have been removed from the analysis, though this would not of course account for the findings of Adelstein and White. An examination of the total number of deaths from causes other than those which are 'social class-related' shows that more than half of them (20 931 out of 37 124) were attributed to congenital defects. Adelstein *et al*¹⁸ showed that for infant deaths from congenital defects from 1975-1977 there was indeed a social class gradient: children of fathers in Social Classes IV and V were about one-and-a-half times more likely to die from a congenital defect than those whose fathers were in Social Classes I and II. The same effect is indicated in a less marked way for children aged between 1 and 10 in the study by Adelstein and White¹⁸ of deaths between 1959 and 1963. This would suggest that the findings of high PMRs for occupation groups 24 and 25 may be at least partly due to an artefact.

The present report differs from those previously published in that we have analysed occupations of the fathers as recorded on death registrations instead of those relating to the time of birth. If it is assumed that preconception events are relevant to the aetiology of childhood cancer, that is, that the postulated association may be the result of genetic damage, then the occupation at the time of the child's birth is the one of interest. If, on the other hand, the effect is assumed to be a postnatal one, then the occupation at the time of the child's death may in some cases be a better indication of the hazard.

Table 5 Proportional mortality ratios for deaths from specified types of neoplasm among children of fathers in professional and managerial occupations

	Kidney		Brain		Leukaemia		Other neoplasms		All neoplasms		
Occupations	Deaths	PMR	Deaths	PMR	Deaths	PMR	Deaths	PMR	Deaths	PMR	*All deaths
1959-63											
Administrators and managers; professional, technical workers, artists	30	116	152	137	239	141	134	117	555	132	3 557
All occupations	270	100	1161	100	1771	100	1193	100	4395	100	37 124
1970-72											
Administrators and managers; professional, technical workers, artists	19	108	136	130	169	123	110	125	434	125	2 618
All occupations	128	100	760	100	1000	100	637	100	2525	100	18 978

*Excluding deaths from social class-related causes.

The results presented here do not strongly support any of the previously suggested associations between childhood cancer and paternal occupations. Possible explanations are that the occupation recorded is the one at death, that occupations on death certificates are less precisely recorded than those used in some previous studies, and that the method of classification used here does not produce sharply defined occupational groups. Moreover, for reasons discussed above, the method of analysis, by proportional mortality ratios, may have obscured some relationships.

However, it should be remarked that the various earlier studies have not reported consistent relationships and it is reasonable to conclude that there is at present no unequivocally established association between any parental occupation and childhood cancer.

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