

schoolchildren and diagnosed before 1971 which was the year when the National Cancer Registry first passed on details to the NHS Central Register. Since then three other cases of cancer have been reported in the follow up of these schoolchildren, which is about one more than the expected number (2.04) of non-fatal cases, plus two cases of carcinoma in situ of the cervix uteri compared with 1.79 expected.

Overall 10 deaths were reported among children in the schools cohort compared with 12.69 expected at national rates—a deficit of about 20%. Apart from the one death from cancer the remaining nine deaths were all certified to “injury and poisoning,” which is the largest cause of death nationally for the ages that these children have achieved.

Of some concern in this study is the 93% trace rate of the schoolchildren in the NHS Central Register. The 7% shortfall may have occurred, for instance, because of inaccuracies in the children's details that were recorded in the three school registers and difficulties in tracing entries in the Central Register from deficiencies in its construction during the early birth years of this study. It is not known whether these deficiencies, which resulted from parents not applying for welfare foods, come from any specific subgroup of families. For this and other reasons we are continuing to investigate ways of successfully identifying the untraced follow up records.

We thank the Registration Division of the Office of Population Censuses and Surveys, the former headmistresses of Singing Surf and Calder Girls Schools, the Cumbrian County Council Education Department, and the headmaster of Seascale School for their cooperation in identifying records on children included in the study. We also thank the National Health Service Central Register for providing follow up details and many staff of the Medical Research Council Environmental Epidemiology Unit who have helped in various ways, particularly Dr Michael Snee for valuable advice, Mr Paul Barnard for the computer analyses, and Miss Brigid Grimes for preparing the manuscript. Professor M Bobrow, Dr V Beral, and Dr P G Smith kindly commented on an earlier version of the paper. The study was approved by the British Medical Association Ethical Committee and the West Cumbrian Ethics of Research Committee and was supported partially by a grant from the Department of Health and Social Security.

References

- 1 Black D. *Investigation of the possible increased incidence of cancer in West Cumbria*. London: HMSO, 1984.
- 2 World Health Organisation. *International classification of diseases, ninth revision*. Geneva: WHO, 1977.
- 3 Office of Population Censuses and Surveys. *Cancer statistics, registrations, 1971-83, England and Wales*. London: HMSO, 1979-86. (Series MB1, Nos 1, 2, 4, 5, 7, 8, 10-15.)
- 4 Draper GJ, Birch JM, Bithell JF, et al. *Childhood cancer in Britain: incidence, survival and mortality*. London: HMSO, 1982. (Office of Population Censuses and Surveys, Studies on Medical and Population Subjects No 37.)

(Accepted 16 June 1987)

Follow up study of children born to mothers resident in Seascale, West Cumbria (birth cohort)

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Abstract

Records on 1068 children who were born to mothers resident in Seascale Civil Parish during 1950-83 were studied. There was a large degree of mobility among the families, and nearly half of the children did not subsequently attend the main local school. Use of the National Health Service Central Register, however, enabled us to follow up the children's records regardless of place of residence. The excess of leukaemia among Seascale children first supported from the analysis of geographical areas is confirmed. There were five deaths from leukaemia identified to 30 June 1986 compared with 0.53 expected at national rates—a ratio of 9.36 (95% confidence interval 3.04 to 21.84). One of these deaths occurred after the child had left Seascale. There were four deaths from other cancers compared with 1.06 expected—a ratio of 3.76 (95% CI 1.02 to 9.63). In addition, three further cases of cancer, apart from the deaths, were reported compared with 1.19 expected since 1971—a ratio of 2.53 (95% CI 0.52 to 7.40). For other causes of death, including stillbirths and infant

mortality, there was a reported deficit compared with national rates, some of which at least was to be expected on the basis of the social class composition of the population of Seascale.

In view of the importance of this cohort of births continued follow up is planned, with the possibility of extending it to include births since 1983, and the methods available for this type of study will be examined further.

Introduction

In November 1983 a Yorkshire Television programme (“Wind-scale: the nuclear laundry”) suggested that there was an excess incidence of childhood leukaemia in the village of Seascale, which is close to the Sellafield nuclear fuel reprocessing site on the coast of Cumbria. The results of various studies supported this observation and led to the Black inquiry recommending further epidemiological investigations.¹

Part of the rationale behind the recommendations was that studies of mortality or incidence of disease on a geographical basis suffer from two potential weaknesses. Firstly, they rely on population figures from decennial censuses for the denominators used in the calculation of area rates, whereas the deaths or cases of cancer that form the numerator typically are those that occur in the area over several years before and after a census. Thus no account can be taken of variations in population size from births, deaths, and migrations that will have taken place during these years. Secondly, any deaths or cases of cancer among children who live for some period of time in an area that occur after they have left will not be included in the numerator of the local rate. Such features are of special concern in an area like Seascale where the population, employed largely at Sellafield, is reported to be particularly mobile.¹

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Among four recommendations in the Black report for further epidemiological studies, the second was that "a study should be carried out of the records on all children born since 1950 to mothers resident in Seascale at the time of birth." This paper reports the methodology and the findings on mortality and cancer of this follow up study.

Methods

Information on each birth registered since 1 January 1950 to a mother whose residential address in her child's birth entry mentioned "Seascale" was abstracted by the registration division of the Office of Population Censuses and Surveys. This required an extensive clerical search through microfilm records of births over several registration districts to the end of 1983, which was the latest possible date at the time of searching. In an attempt to ensure the inclusion of all hospital as well as home births the search included other areas in addition to the main local registration district of Whitehaven. Table I lists the districts in which it was considered possible that births to mothers who were resident in Seascale might have taken place and for which registers were searched before and after local authority boundary reorganisation during 1974. The home addresses given in the birth entries were examined against maps of and lists of addresses inside Seascale Civil Parish. Only births where the mother's residential address was inside the civil parish boundary, as opposed to having Seascale as a descriptive postal address, were included.

TABLE I—Registration districts for which the Office of Population Censuses and Surveys microfilm records were searched to identify births to mothers who were resident in Seascale by calendar period and numbers included in the study

Calendar period	Registration district	No in birth cohort*
January 1950-March 1974	Alston	0
	Barrow-in-Furness	2
	Border	0
	Carlisle	39
	Cockermouth†	24
	Millom	0
	Penrith	0
	Whitehaven	808
	Wigton	0
	April 1974-December 1983	Appleby
Barrow-in-Furness		0
Carlisle		0
Cockermouth†		0
Kendal		0
Millom		0
Penrith		0
Ulverston		0
Whitehaven		191
Wigton		0

*Other potential members of the Seascale birth cohort were found but then eliminated as mentioned in the text (see also table II). Four "transferable" births (see text) were identified as registered outside the districts in the table—three in the Liverpool area and one in Northumberland.

†Cockermouth Registration District included Workington and Maryport.

A search was also made in the register of births held locally by the West Cumbria Health Authority at Flatt Walks Clinic and the West Cumberland Hospital in Whitehaven for immunisation and child welfare purposes. This register contains less identifying information on each child so that, for example, forenames were not always recorded, but details on any possible Seascale births found in this way were abstracted. The two differently obtained sets of births were then checked by computer against each other using the recorded information on surname and date of birth. For children on the West Cumbria list who were not on the Office of Population Censuses and Surveys list a further search was made in the Office of Population Censuses and Surveys microfilm records at the appropriate date, and information on birth entries was abstracted where found.

For all eligible births thus identified details were sent to the National Health Service Central Register in Southampton with a request for vital status data, including information on deaths, cancer registrations, and emigrations. In addition, we were notified by the NHS Central Register of all family practitioner committee areas in which the children had been recorded since birth as registered with general practitioners and dates, which allowed estimates to be made of durations of residence in Cumbria. This information was supplemented both by a search for the parents' names in the annual Seascale Electoral Registers (the electoral ward and civil parish boundaries

are the same) and by information from the Seascale Local Authority school register about attendance and dates to obtain estimates of length of residence in Seascale for each child. The West Cumbria Health Authority register was also searched for recorded information on deaths or cases of cancer among the Seascale births. None of the children or their parents have been approached personally for information.

In this paper mortality up to 30 June 1986 among the children identified as born to mothers who were resident in Seascale is analysed and compared with that expected at national rates. Some of the follow up information and deaths in the study are of people who have passed childhood, such as those born before 1970, but the term children is used throughout the paper to refer to the members of the birth cohort. The person years method of analysis was used, incorporating calendar period, cause, sex, and age specific death rates for England and Wales. Confidence intervals were calculated using standard methods based on the Poisson distribution.

Results

SEASCALE BIRTH COHORT

Table II gives details of how the "Seascale birth cohort" was assembled.

TABLE II—Births identified during 1950-83 to mothers who were resident in Seascale by source of information

Source of identification and outcome	No
<i>First OPCS birth register search (n=1202):</i>	
Included in birth cohort	990
Address outside Seascale Civil Parish	211
Duplicate registration	1
<i>First West Cumbria register search:</i>	
Possible "Seascale" births not found at OPCS (n=92):	
Address outside Seascale Civil Parish	5
Birth entry found at second OPCS search:	80
Included in birth cohort	61
Address outside Seascale Civil Parish	16
Duplicate entry (among original 1202)	3
No trace at OPCS	3
Stillbirths (no live birth entry)	4*
"Transferable" births (n=22)	
Birth entry found at second OPCS search:	18
Included in birth cohort	16
Address outside Seascale Civil Parish	2
Born in Scotland	4
<i>Second West Cumbria register search:</i>	
Included in birth cohort	1
Total included in birth cohort (relevant livebirths)	1068

OPCS=Office of Population Censuses and Surveys.

*A further five stillbirths were identified both by OPCS and in the West Cumbria register.

The original Office of Population Censuses and Surveys search identified 1202 birth entries with Seascale home addresses, of which 211 were later found to be outside the civil parish boundary and one a duplicate birth registration (a reregistration after the subsequent marriage of the child's parents).

Among the 1056 Seascale births found in the West Cumbria register 92 did not apparently match with any from the 1202 children identified by the Office of Population Censuses and Surveys using the information available. Of these 92 births, five children with addresses outside Seascale Civil Parish were excluded. A second search was made at the Office of Population Censuses and Surveys for the remaining 87, during which 80 birth entries were identified; three could not be traced and four were found to be stillbirths (stillbirth entries are kept on separate microfilms). Among the 80 birth entries traced three were duplicates of births found in the original Office of Population Censuses and Surveys search for which the matching had not been clear previously, 16 had addresses outside Seascale Civil Parish, and 61 were extra births to be included in the study. In addition to the four stillbirths mentioned above, searches at the Office of Population Censuses and Surveys and at West Cumbria each identified five further stillbirths during 1950-83.

In addition to entries for births that took place locally the West Cumbria Health Authority register has a separate section with details of births registered outside the area which are subsequently "transferred in" and recorded for, for instance, health visiting and immunisation. Details of a further 22 potential Seascale births were abstracted from this section and sent to the Office of Population Censuses and Surveys for further searching. Consequently, four were found to have been born in Scotland and two others

had addresses outside Seascale Civil Parish. Thus 16 more births were added to the birth cohort.

Subsequently, during a search in the West Cumbria register for deaths among children born to Seascale mothers a further eligible birth was identified and included in the study. Thus the count of live births from 1950 to 1983 to mothers with a residential address in Seascale Civil Parish was $990+61+16+1=1068$ births. The distribution of registration districts in which the birth entries were found (table I) shows that the Office of Population Censuses and Surveys search covered a wider area than that in which most Seascale births were actually registered. In fact since 1971 all entries were in Whitehaven following the wide use of the maternity unit opened during 1964 at the West Cumberland Hospital. Including the nine stillbirths the final total in the Seascale Birth Cohort is 1077 births.

Table III gives the numbers of live births and stillbirths to mothers who were resident in Seascale by calendar year from 1950 to 1983. The numbers

TABLE III—Live births by sex and stillbirths during 1950-83 to mothers who were resident in Seascale Civil Parish

Year of birth	No of live births			Sex ratio M/F	Stillbirths
	Males	Females	Total		
1950	12	15	27	0.80	1
1951	10	15	25	0.67	2
1952	18	22	40	0.82	1
1953	27	19	46	1.42	
1954	20	18	38	1.11	1
1955	13	14	27	0.93	1
1956	14	21	35	0.67	
1957	19	24	43	0.79	
1958	25	16	41	1.56	1
1959	20	16	36	1.25	
1960	25	21	46	1.19	
1961	25	18	43	1.39	
1962	21	15	36	1.40	
1963	32	21	53	1.52	
1964	21	23	44	0.91	1
1965	17	23	40	0.74	
1966	24	10	34	2.40	
1967	14	12	26	1.17	
1968	15	15	30	1.00	
1969	22	17	39	1.29	
1970	16	14	30	1.14	
1971	16	21	37	0.76	
1972	11	13	24	0.85	1
1973	12	15	27	0.80	
1974	12	10	22	1.20	
1975	9	11	20	0.82	
1976	7	15	22	0.47	
1977	7	6	13	1.17	
1978	8	16	24	0.50	
1979	8	2	10	4.00	
1980	9	11	20	0.82	
1981	15	6	21	2.50	
1982	18	14	32	1.29	
1983	10	7	17	1.43	
1950-83	552	516	1068	1.07	9

of live births by year differ slightly from those given in figure 2.1 of the Black report, which was based on an earlier search of the West Cumbria Health Authority register.¹ The annual number averaged about 30 over the period, with a peak in the early 1960s and somewhat lower numbers since the middle 1970s. This time trend is similar to figures for births in England and Wales overall, although the recent decrease in Seascale is more pronounced. The ratio of male to female births during the 34 year period was 1.07, similar to the national ratio of 1.06 during these years, with no evidence of any time trend.

The nine stillbirths occurred mainly in the earlier years, as would be expected from national trends in stillbirth rates, which declined from roughly 25 per 1000 births in the early 1950s to about six per 1000 births in the early 1980s. Overall the stillbirth rate—9 of 1077 or 8.4 per 1000 births—is low compared with the period average of 15 per 1000 for England and Wales. The trend, however, in stillbirth mortality according to social class—for example, from 8.8 per 1000 births in social class I to 17.5 per 1000 births in social class V during 1970-2²—may partly explain the low rate among the births in the village, most of whose population worked at Sellafield. The percentages of the economically active male population in Seascale in social class I in recent censuses were far higher than national figures—that is, 43% in Seascale for 1961 compared with 4% nationally, 47% for 1971 compared with 5%, and 28% for 1981 compared with 6% (Office of Population Censuses and Surveys, unpublished data). These differences for social class I are extreme, but the general distribution by social class is

indicated, for example, in the 1981 census where the percentages were: social class I (professional occupations) 28% in Seascale, 6% in England and Wales; social class II (intermediate) 13%, 22%; social class III (skilled) 42%, 46%; social class IV (partly skilled) 14%, 16%; social class V (unskilled) 0%, 6%; and "unclassified" 3%, 5%.

DURATION OF RESIDENCE IN SEASCALE AND CUMBRIA

In the three different ways outlined earlier table IV gives figures on approximate length of residence in Seascale and Cumbria for the 1068 live births in the birth cohort. Table IV(a) gives the numbers of children who had become pupils at the main school in Seascale by November 1984. (For a description of the Seascale schools see accompanying paper.) If the final four years 1980-3 are excluded then 556 out of the 978 (57%) children attended the school. The remaining 422 (43%) were not found on the school register and can be presumed to have moved out of Seascale between birth and school age. This percentage varied little over the 30 years. Forty four (4.5%), however, are known to have attended a school for preschool age children in Seascale which was open between 1949 and 1968 (see accompanying paper).

Table IV(b) gives information about the appearance of parents' names on the Seascale Electoral Register from before the birth of each child up to 10 October 1984, the qualifying date for the 1985 register. Of the 28 births where the parents' names were not on the succeeding electoral register, 23 took place within one year of the date of their qualification for the previous register. Omitting the years 1980-3 as before, 427 out of 933 (46%) identified names had been taken off the electoral register shortly preceding or within

TABLE IV—Approximate length of residence in Seascale or Cumbria of children born during 1950-83 to mothers who were resident in Seascale Civil Parish

(a) According to Seascale Local Authority School register up to November 1984

Years of birth	Name on register			Total
	No	Yes	Total	
1950-4	84	92	176	
1955-9	72	110	182	
1960-4	101	121	222	
1965-9	60	109	169	
1970-4	67	73	140	
1975-9	38	51	89	
(1980-3)*	(81)	(9)	(90)	
1950-83	503	565	1068	

*Children born during these years had mainly not reached school age by November 1984.

(b) According to parents' entry on local Seascale Electoral Registers from 1950 to 1985

Years of birth	Years from birth to parents leaving electoral register					Parents on 1985 electoral register	Parents not found on electoral register	Total
	<0	0-4	5-9	10-14	15+			
1950-4	1	80	28	9	20	28	10	176
1955-9	5	64	32	18	16	39	8	182
1960-4	6	94	38	7	11	52	14	222
1965-9	9	59	26	6	3	63	3	169
1970-4	3	65	14	7	—	44	7	140
1975-9	4	37	6	—	—	39	3	89
1980-3	0	24	—	—	—	65	1	90
1950-83	28	423	144	47	50	330	46	1068

(c) According to registrations with a general practitioner in the Cumbria Family Practitioner Committee (FPC) area up to December 1984

Years of birth	Years from birth to non-registration with Cumbria FPC					Still with Cumbria FPC	Unknown	Total
	0-4	5-9	10-14	15-19	20+			
1950-4	72	27	6	35	15	17	4	176
1955-9	56	24	7	50	12	31	2	182
1960-4	65	11	12	42	11	77	4	222
1965-9	32	8	3	25	—	100	1	169
1970-4	34	5	5	—	—	94	2	140
1975-9	16	3	—	—	—	70	0	89
1980-3	16	—	—	—	—	74	0	90
1950-83	291	78	33	152	38	463	13	1068

five years after the birth. This percentage is comparable to the 43% of children who did not attend the local school. Indeed there is a large overlap between the names of these 427 parents and of the 422 children not on the school register, 360 (85%) of the latter being included in the former, as would be expected and as is suggested by the relevant numbers for the separate quinquennial birth groups in tables IV(a) and (b). Of the 1068 children, 46 parents' names (4%) were not found on the electoral registers, and 330 (31%) were still on in 1985. More and more parents' names were taken off the electoral register over the years since the births, suggesting a continued movement of the children out of Seascale. Among the children who had reached their 15th birthday by the last electoral register examined—that is, born before 1970—532 out of 714 (75%) identified parents were no longer registered. Although such information cannot be equated exactly with children moving out of Seascale, especially at older ages, it is a reasonably good indicator.

Table IV(c) gives the number of registrations of the children with general practitioners in the Cumbria family practitioner committee area and the duration, as reported by the NHS Central Register up to December 1984. This information is less precise than that in tables IV(a) and (b) in relation to residence in Seascale since a change in family practitioner committee registration indicates only a movement out of Cumbria rather than from Seascale. At the end of 1984, excluding the 13 children for whom no family practitioner committee registration was reported, 592 out of 1055 (56%) children had apparently left Cumbria. As might be expected, there was a large increase in non-Cumbria family practitioner committee registrations during the period 15-19 years after birth, corresponding to the children reaching school leaving age. That this movement is largely independent of their parents is indicated by the lack of any similar rise in numbers during these same years in table IV(b).

The general tendency shown in the three parts of table IV concurs with the suggestion of a mobile population in Seascale. Some 40% of children born in Seascale did not stay to attend the local school, a similar percentage of parents came off the electoral register within five years of their child's birth, and over half the children had moved out of Cumbria by the end of 1984.

MORTALITY AND CANCER FOLLOW UP

Because of the availability of NHS numbers from the birth entries the NHS Central Register traced all the children's records. Among the 1068 live births in the Seascale birth cohort 27 deaths and 43 emigrations were reported to us, and the remaining 998 children were thought to be alive.

Table V gives the numbers of deaths by cause among the cohort and the numbers expected according to death rates for England and Wales. As expected from earlier reports⁵ there is an excess mortality from leukaemia—five deaths compared with 0.53 expected. Four of these were known to the Black inquiry (cases 3, 4, 5, and 6 of table 2.1¹), and the fifth was a death from leukaemia that occurred after the child had left Seascale. She was born in 1950, died at age 3 years in 1954, and death was certified as due to "subacute lymphatic leukaemia." She had lived in Seascale to the age of about 3 years according to the electoral registers and family practitioner committee registrations. This is the only death from leukaemia or lymphoma reported among children born in Seascale in addition to those known to the Black inquiry, since the one death from the latter cause, in a child after moving away from Seascale, was listed (case 14 of table 2.3¹). The other three deaths from cancer, compared with 0.88 expected, include one known previously—certified as "retroperitoneal sarcoma" (case 26 of table 2.4¹)—and two occurring after the children had left Seascale. One of these was certified as "metastatic squamous carcinoma of the tongue" in a 28 year old man, and the other as a "Wilms's tumour of the left kidney" in a girl aged 4.

TABLE V—Numbers of deaths by cause to 30 June 1986 among children born during 1950-83 to mothers who were resident in Seascale Civil Parish compared with deaths expected at national rates

Cause of death*	No of deaths		O/E	95% Confidence interval for O/E
	Observed (O)	Expected (E)		
Malignant neoplasms (140-208):	9	1.60	5.63	2.58 to 10.69
Non-Hodgkin's lymphoma (200,202)	1	0.12	8.45	0.21 to 47.10
Hodgkin's disease (201)	0	0.07	0	0 to 53.71
Leukaemia (204-208)	5	0.53	9.36	3.04 to 21.84
Other cancers	3	0.88	3.42	0.71 to 10.00
Other causes	18	30.70	0.59	0.35 to 0.93
All causes	27	32.30	0.84	0.55 to 1.22

*Figures in parentheses are code numbers in the International Classification of Diseases (9th revision).³

TABLE VI—Numbers of deaths by age and sex to 30 June 1986 among children born during 1950-83 to mothers who were resident in Seascale Civil Parish compared with deaths expected at national rates

Category	No of deaths		O/E	95% Confidence interval for O/E
	Observed (O)	Expected (E)		
Age (years):				
Under 1	12	21.53	0.56	0.29 to 0.97
1-4	6	3.20	1.88	0.69 to 4.09
5-9	1	1.55	0.64	0.02 to 3.59
10-14	0	1.14	0	0 to 3.23
15-19	3	2.04	1.47	0.30 to 4.31
20-24	2	1.53	1.31	0.16 to 4.74
25-29	2	0.87	2.30	0.28 to 8.32
30+	1	0.45	2.24	0.06 to 12.49
Sex:				
Male	15	19.33	0.78	0.43 to 1.28
Female	12	12.97	0.93	0.48 to 1.62
Calendar year of follow up:				
1950-4	3	4.78	0.63	0.13 to 1.83
1955-9	7	4.93	1.42	0.57 to 2.92
1960-4	3	5.94	0.51	0.10 to 1.48
1965-9	3	4.72	0.64	0.13 to 1.86
1970-4	3	4.37	0.69	0.14 to 2.01
1975-9	4	3.38	1.18	0.32 to 3.03
1980-6	4	4.18	0.96	0.26 to 2.45
Calendar year of birth:				
1950-4	8	8.12	0.99	0.43 to 1.94
1955-9	9	6.81	1.32	0.60 to 2.51
1960-4	5	7.22	0.69	0.23 to 1.62
1965-9	4	4.45	0.90	0.25 to 2.30
1970-4	1	3.04	0.33	0.01 to 1.84
1975-9	0	1.49	0	0 to 2.48
1980-3	0	1.17	0	0 to 3.16
Total	27	32.30	0.84	0.55 to 1.22

In contrast with the excess of deaths from cancer in the birth cohort there is a deficit against national figures of some 40% for deaths from other causes—18 compared with 30.70 expected. Table VI shows that this relates particularly to infant deaths under 1 year of age—12 deaths were reported compared with 21.53 expected. During the period of this study infant mortality in England and Wales fell from about 30 per 1000 live births around 1950 to about 10 per 1000 live births in the early 1980s, whereas in this birth cohort it was near 11 per 1000 live births. Of these 12 deaths, eight only were originally notified from the NHS Central Register. Because of this apparently small number a thorough search was made through the West Cumbria Health Authority register where an additional four deaths before the mid-1960s were identified. There was a potential problem with the recording of deaths in the Central Register owing to the fact that before 1 April 1969 only age at death, not the date of birth, was reported to the Central Register, which led to difficulties in linkage in the register, particularly for common names and for births during the period 1952-63 when there was a deficiency of about 15% in their alphabetical index. The ages of the infant deaths, however, show a similar distribution to the national figures for this period—five of the 12 were on the day of birth and four more within the first week of life, which does not suggest that early deaths may be particularly vulnerable to omission.

Infant mortality in the birth cohort fell during the study, with seven infant deaths out of 358 births during the 1950s, five out of 391 births during the 1960s, and none out of the succeeding 319 births. Again, as for stillbirths, the social class composition of Seascale and the trend in infant mortality—for example, from 12 per 1000 live births in social class I to 31 per 1000 live births in social class V during 1970-2²—may partly explain the low rate. There is no suggestion that rates are low in general in the locality. Thus for a comparable period of years, 1969-73, infant mortality in the combined rural districts of Cumberland at 20 per 1000 live births was slightly greater than that of 18 per 1000 live births in England and Wales.⁶

Table VI shows that at ages over 1 year there is an excess mortality of 15 observed compared with 10.77 expected (O/E = 1.39, 95% confidence interval 0.78 to 2.30) due entirely to the excess of cancer deaths (nine observed, 1.53 expected) particularly leukaemia (five observed, 0.51 expected). The six non-cancer deaths (compared with 9.24 expected) in children over 1 year of age were recorded as from different causes, including acute pyelitis, congenital heart disease, suicide, bronchopneumonia, myocardial infarction, and a traffic accident.

Also, there is no notable difference between the death rates of boys and girls born in Seascale, nor any suggestion of a time trend by calendar year of follow up. On the other hand, there is an apparent decline in mortality relative to expected for children born in successive five year periods, which largely reflects the fall in stillbirth and infant mortality discussed earlier. Death rates for young persons in Cumberland, other than infants, are

TABLE VII—Number of deaths* by cause to 30 June 1986 among children born during 1950-83 to mothers who were resident in Seascale Civil Parish compared with deaths expected at national rates by approximate residence in (a) Seascale or (b) Cumbria (a) According to parents' entry on local Seascale Electoral Registers from 1950 to 1985

Cause of death	During parents' residence in Seascale†	No of deaths		O/E	95% Confidence interval for O/E
		Observed (O)	Expected (E)		
Leukaemia	Yes	4	0.24	16.52	4.50 to 42.28
	No	1	0.27	3.75	0.10 to 20.88
Other malignant neoplasms	Yes	1	0.40	2.53	0.06 to 14.07
	No	3	0.62	4.88	1.01 to 14.26
Other causes	Yes	11	22.88	0.48	0.24 to 0.86
	No	5	6.41	0.78	0.25 to 1.82
All causes	Yes	16	23.52	0.68	0.39 to 1.11
	No	9	7.23	1.23	0.56 to 2.34

(b) According to registrations with a general practitioner in the Cumbria Family Practitioner Committee area up to December 1984

Cause of death	During Cumbria GP registration‡	No of deaths		O/E	95% Confidence interval for O/E
		Observed (O)	Expected (E)		
Leukaemia	Yes	3	0.32	9.35	1.93 to 27.31
	No	2	0.21	9.57	1.16 to 34.56
Other malignant neoplasms	Yes	2	0.50	4.01	0.49 to 14.48
	No	2	0.56	3.60	0.44 to 12.99
Other causes	Yes	13	25.47	0.51	0.27 to 0.87
	No	5	5.01	1.00	0.32 to 2.33
All causes	Yes	18	26.29	0.69	0.41 to 1.08
	No	9	5.77	1.56	0.71 to 2.96

*Children were excluded from this table if their data on Seascale Electoral Registers or general practitioner registrations were unknown.

†Person years of follow up during parents' Seascale residence: yes 8711; no 11750.

‡Person years of follow up during Cumbria registration with general practitioner: yes 11898; no 9396.

slightly lower than in England and Wales overall, but incorporating an adjustment for this into the expected numbers has no real effect on the interpretation of results in this paper.

In addition to the nine deaths from cancer in table V three further cases of cancer were notified from the NHS Central Register. Two of these patients, who lived in Seascale at diagnosis, were included in the Black report (case 7 of table 2.1¹ diagnosed as "acute lymphoblastic leukaemia" and case 17 of table 2.3¹ diagnosed as "non-Hodgkin's lymphoma"). A third case is a man diagnosed with a "malignant melanoma" at 28 years of age after having moved away from Seascale.

Table VII gives mortality findings in relation to estimated residence in Seascale or Cumbria. In table VII(a) figures are given for observed and expected deaths by cause both during and outside periods when the children's parents were on the Seascale Electoral Register (see table IV(b)). The observed/expected ratios are greater than unity for leukaemia and for other cancers both during and outside Seascale "residence"; although two of the ratios are each based on one death, the other two are statistically significant. In table VII(b) similar information is presented for periods during and outside the children's registration with a general practitioner in Cumbria (see table IV(c)). As would be anticipated the expected numbers of deaths in association with Cumbrian Family Practitioner Committee registrations are larger than those associated with presence on the Seascale Electoral Register. In this analysis similarly high observed/expected ratios are found for both leukaemia and other cancers in each "residence" category. One of the four deaths from leukaemia where the parents were still on the electoral register in Seascale was a child whose general practitioner registration had been changed to outside Cumbria. The low level of mortality from other causes during Seascale/Cumbria "residence" shown in tables VII(a) and (b) respectively is largely associated with the low rate of infant deaths described earlier, but it is noticeable in both sections of table VII that overall mortality is higher outside than during Seascale/Cumbria "residence."

Discussion

One of the important purposes of this study was to investigate further the findings of the earlier geographical analyses of the incidence of cancer among young people in Seascale where the main

observation had been an excess of leukaemia. We have corroborated that result in reporting five deaths from leukaemia among children born during 1950-83 to mothers who were resident in Seascale compared with 0.53 expected from death rates in England and Wales. Thus by approaching the estimation of the local rate by another method we found a similar estimated level to that originally suggested—that is, about 10-fold higher than expected on national rates. The previous figure of 10-fold referred to children under the age of 10 years,¹ whereas this study reported on births followed up to the ages reached by 30 June 1986. Examination of leukaemia deaths up to age 10 years only in this study, however, produces a similar outcome of four observed compared with 0.32 expected. During the years 1959 to 1978, for which mortality data for the county of Cumberland as a whole are available, the leukaemia death rate was 12% lower than in England and Wales at ages 0-24 years.⁷ Using the county figures rather than the national figures for comparison for the Seascale children would raise the observed/expected ratio in table V from 9.36 to 10.59 (95% CI 3.46 to 24.91). We know, however, that a sizable number of the children spent many of the years between 0 and 24 years of age outside Cumbria (table IV(c)). Also these figures exclude the results on Seascale schoolchildren given in the accompanying paper.

There is some evidence that childhood leukaemia rates are highest in social class I and show a declining trend to social classes IV and V.^{8,9} For example, in figures for children aged 0-14 years in England and Wales during 1959-63 the annual leukaemia mortality rates varied from 44 per million in social class I to 37 per million in social class V, with the lowest rate of 31 per million in social class IV.⁸ On the other hand, in a report on childhood leukaemia up to the age of 15 years in north west England (which includes Cumbria) during 1954-77 Birch and her colleagues reported that the social class distribution of the cases "did not differ from the population as a whole."¹⁰ It thus seems unlikely that social class factors are sufficient to explain the raised level of leukaemia among the Seascale birth cohort. Clearly there was a lot of movement out of Seascale, as shown in table IV, whether measured by school attendance or by registration on the Seascale Electoral Roll or with the Cumbria Family Practitioner Committee. By taking account of the mobility of the local population, which caused concern about the use of census figures for calculating death rates, the excess has been confirmed. This finding must remove any doubt that there had previously been an artefact due to the possible underestimation of the appropriate population at risk.

Of the five deaths from leukaemia, four occurred while the children were still resident in Seascale and the other one after the child left the area. The first four deaths were expected to be found in this study as the children were previously known to have been born and had their leukaemia diagnosed in Seascale.¹ If they had not been identified, both in the searches of the Office of Population Censuses and Surveys and West Cumbria birth registers and in the NHS Central Register follow up, this would have cast doubts on the procedures used here. These four and other relevant cases of cancer listed in the Black report, however, were all reported from the Central Register, the only exception being for case 25 of table 2.4,¹ which is incorrectly given there as born in "Seascale" rather than "Other Millom Rural District." The one death from leukaemia after the child moved from Seascale was reported in a girl aged 3 years who was one of the earliest births in the study. She would have lived some 3 years in Seascale during the early period of operation of the Sellafield site.

As well as the excess of leukaemia deaths in the Seascale birth cohort there is an increase of deaths from other cancers though also based on small numbers. Compared with an expected number of deaths on national rates of 1.06 there have been four deaths reported, a ratio of 3.76 (95% CI 1.02 to 9.63). These are from various cancers as identified earlier, but include one case of non-Hodgkin's lymphoma. Three of these deaths occurred after the children left Seascale.

For other causes of death there has been a deficit in the reported mortality rates among the Seascale birth cohort related particularly to infant mortality. Extensive searches were made in available records to assess whether this deficit was due to missing deaths that

should have been reported. Four infant deaths not identified in the NHS Central Register were found in the West Cumbria register, and all took place before April 1969 when it was not possible to link successfully all deaths into the Central Register owing to the insufficient detail supplied. The rate of stillbirths reported is of a similar apparently low level compared with national figures. All nine stillbirths, however, were found independently in both the Office of Population Censuses and Surveys and the West Cumbria registers. The special social class composition of the Seascale population may have contributed importantly to the low rates for stillbirths and infant mortality.

For cancer registrations, rather than deaths, three were reported to us from the NHS Central Register. The coverage is, however, limited to the years since 1971 when the National Cancer Registration system first notified cases to the Central Register. Thus only 14 years of the follow up period can be included in the present analysis since notification of cancer cases to the Central Register has not yet been made by all regional registers beyond 1984. Using published annual figures for cancer registration by age and sex¹¹ and subtracting the number of expected deaths during the same period, we calculated that 1.19 non-fatal cancers would be expected among the birth cohort from 1971 to 1984 (observed/expected = 2.53, 95% CI 0.52 to 7.40). Although this is an approximate calculation, as cancer deaths and registrations occurring in a defined calendar period do not refer to exactly the same cases, it does indicate a relative excess also, though not statistically significant, of living cases of cancer. The case-control study of childhood cancers in West Cumbria that we are carrying out is aimed at obtaining pertinent information on cases in this analysis and on cases diagnosed in other areas of West Cumbria.

The "flagging" of the 1068 birth records in the Central Register for this study means that follow up can be continued beyond the current date of reporting. In addition, it is possible to include births that have taken place from 1984 onwards to examine the records of children born recently, which is particularly appropriate for childhood leukaemia since most cases are diagnosed in children under 5 years. We will also examine solutions to the difficulties caused in this study and others like it by the lack of complete linkage of birth, death, cancer registration, and other records in the NHS Central Register. This includes, for example, investigating linkage

of the records on children in this study into the national records held by the Childhood Cancer Research Group (G J Draper, personal communication).

We thank the Registration Division of the Office of Population Censuses and Surveys, the Cumbria County Council Education Department, and the headmaster of Seascale School for their cooperation in identifying records on children included in this study. We also thank various people at the West Cumberland Hospital and Flatt Walks Clinic in Whitehaven for their help and the National Health Service Central Register for providing follow up details. Many staff of the Medical Research Council Environmental Epidemiology Unit have helped, particularly Dr Michael Snee, who gave valuable advice; Mr Paul Barnard, who performed the computer analyses; and Miss Brigid Grimes, who prepared the manuscript. Professor M Bobrow, Dr V Beral, and Dr P G Smith kindly commented on an earlier version of the paper. The study was approved by the British Medical Association Ethical Committee and the West Cumbrian Ethics of Research Committee and was supported partially by a grant from the Department of Health and Social Security.

References

- 1 Black D. *Investigation of the possible increased incidence of cancer in West Cumbria*. London: HMSO, 1984.
- 2 Office of Population Censuses and Surveys. *Occupational mortality, decennial supplement, 1970-72, England and Wales*. London: HMSO, 1978. (Series DS No 1.)
- 3 World Health Organisation. *International classification of diseases, ninth revision*. Geneva: WHO, 1977.
- 4 Urquhart J, Palmer M, Cutler J. Cancer in Cumbria: the Windscale connection. *Lancet* 1984;ii:217-8.
- 5 Craft AW, Openshaw S, Birch J. Apparent clusters of childhood lymphoid malignancy in northern England. *Lancet* 1984;ii:96-7.
- 6 Office of Population Censuses and Surveys. *Area mortality, decennial supplement, 1969-73, England and Wales*. London: HMSO, 1981. (Series DS No 4.)
- 7 Gardner MJ, Winter PD. Mortality in Cumberland during 1959-78 with reference to cancer in young people around Windscale. *Lancet* 1984;ii:216-7.
- 8 Adelstein AM, White GC. Causes of children's deaths analysed by social class. In: *Child health—a collection of studies*. London: HMSO, 1976:23-40. (Office of Population Censuses and Surveys, Studies on Medical and Population Subjects No 31.)
- 9 Sanders BM, White GC, Draper GJ. Occupations of fathers of children dying from neoplasms. *J Epidemiol Community Health* 1981;35:245-50.
- 10 Birch JM, Swindell R, Marsden HB, Jones PHM. Childhood leukaemia in north west England 1954-1977: epidemiology, incidence and survival. *Br J Cancer* 1981;43:324-9.
- 11 Office of Population Censuses and Surveys. *Cancer statistics, registrations, 1971-83, England and Wales*. London: HMSO, 1979-86. (Series MB1, Nos 1,2,4,5,7,8,10-15.)

(Accepted 16 June 1987)

MATERIA NON MEDICA

What the Hecate?

When I bought my word processor I thought I was acquiring a piece of highly technical equipment that would obey my simplest demands at the touch of a button or two in the same way that my car, my television, and my tape recorder will unhesitatingly do what I want them to.

But I was mistaken. I was soon made aware that somewhere behind its bland façade there lurks a she devil. There is no doubt about the sex. The (male) devil, according to Milton, is a gentleman; my devil is no lady; she is—I hate to have to put it so bluntly—a bitch. It is only too clear that there are three protagonists in the drama. There's myself who knows what I want; the computer affair, who loyally tries to cooperate; and there's Hecate, the she devil, unpredictable, and always poised ready to throw a spanner in the works. For instance, I like to date my correspondence in the top right hand side of the page. Hecate will sometimes whizz it across to the left, not just once, but repeatedly; or again, I may decide that it is time to start a new paragraph: Hecate decides otherwise and insists on tagging my next sentence on the end of the previous paragraph. I will not bore the reader by detailing the clever stratagems that I have to adopt before I can get my own way—even assuming I could remember them.

But today Hecate has really excelled herself in bitchiness. Last night I roughed out a first draft of an article and tucked it away in the computer's memory. This morning I retrieved it and spent several hours working on it, correcting errors, pruning and grafting, and expanding it with a couple of paragraphs. When I was satisfied with this edited version and called for a print out, Hecate threw every possible obstacle in my way. She sent up a message to say that the "Disk was full" (which I swear was a lie), bade me cancel the whole operation, and suddenly whooshed the entire text

downwards, like a roller blind upside down, leaving me with a completely blank screen. And completely blank it obstinately remained, no matter what I tried. Battle was joined. My blood was up. Recklessly I played a devil's tattoo on keys at random, but whatever key I pressed was answered by a derisive squeak, which is Hecate's way of blowing raspberries. There seemed only one way of recovering my edited version and that was to pack it all in for the time being, take a turn or two in the garden, and start afresh at square one; which I did.

At which point Hecate played her joker. When, after the tiresome prelude of descending horizontal lines, the commercial, and what I call the oil rig, I eventually pressed the "Edit" key—what did I get? My last night's rough draft, warts and all. Hecate had been keeping it up her sleeve, ready to confound me, and had wholly eradicated my carefully edited version which is now lost for ever.

The instruction manual that accompanied the machine makes no reference to Hecate—as far as I can tell; I can't be sure, because the manual, weighing 3 lb, has baffled better brains than mine; nor do the handy little exegeses, devised by the more experienced for the likes of me, have anything to say on the matter.

A disturbing thought assails me. Will these words ever see print? I have unmasked Hecate and said some pretty strong things about her. Will she retaliate by obliterating it all? Or will she rejoice in the publicity I have afforded her? Time alone will tell. I can only keep my fingers crossed and hope for the best.

One day I stopped a passing clergyman and asked him if he would be so good as to step inside and exorcise a she devil. I could supply a book—there were several in our spare room—and a candle end left over from the last power cut, but I had no bell except the front door bell which I could ring at a given signal. It was no good. All I got from him was a curious look and a hasty parting of company. Perhaps I should have offered to go private.—
GEORGE H DAY, Mundesley, Norwich.