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Survival from adolescent cancer in Yorkshire, UK

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Abstract

The aim of this study was to investigate survival rates for adolescents with cancer and identify factors associated with differential long-term prognosis in Yorkshire, UK. A survival analysis of a population-based cohort of young adults aged 15–24 years, diagnosed with a malignancy in the former Yorkshire Regional Health Authority between 1985 and 1994 was carried out. The main outcome was death from all causes. Overall survival for the 1097 adolescents with a malignancy increased by 30% between 1985–1989 and 1990–1994 ($P = 0.004$). This improvement was reflected in most subgroups of cancer. Large scale geographical differences in survival rates were observed across Yorkshire, with an increased risk of death in North Yorkshire and Humberside of 34% and 45%, respectively, compared with West Yorkshire. Small scale analyses showed reduced survival in areas of high population density, but no consistent trends were associated with socio-economic status. Improved survival from all cancers in young adults over the last decade is clearly seen. Reasons for differential survival by geographical area are unclear and warrant further investigation.

Keywords: Survival and cancer; Adolescent; Socio-economic status; Population density

1. Introduction

After road traffic accidents and suicide, adolescent cancer is the third most significant cause of mortality in young people in the United Kingdom. In 1993 in England and Wales, there were 375 deaths from cancer in the age range of 15–24 years [1].

Cancer in adolescence differs from that in adults and children: cancer in children is usually caused by a range of developmental tumours, whereas in adults the commonest type of cancer is epithelial in nature (e.g. breast, lung and prostate). Adolescent cancers tend to be a mix of paediatric and adult cancers. Although ICD10 has been used to categorise malignancies in children, this classification scheme is not without its problems when applied to the adolescent and young adult age groups.

Various studies have looked at adolescence in relation to cancer, yet the age range examined has differed quite markedly. For example, Fritschi [2] looked at the incidence of cancer amongst New South Wales adolescents and concentrated principally on the appropriate classification scheme in a study of adolescents aged 10–19 years with cancer between 1972 and 1991. The authors concluded that the childhood classification scheme is appropriate to describe cancer incidence in adolescent age groups, but perhaps requires minor modifications. The classification used in this study was therefore the International Childhood Classification of Cancer (ICCC) [3], which uses tumour morphology as well as tumour site.

The biology of malignant disease largely determines the age groups to be analysed and for the purposes of this study, adolescence was defined as between 15 and 24 years of age. Over the past 20 years, almost all of the care of young children with cancer has been centralised in the regional centres. This has not happened to the same extent with adolescents. The approach to the treatment of adolescents is not directly age-related, but in Yorkshire varies with hospital and with diagnosis. In the more common malignancies in this age group, treatment is more likely to take place at a local level than in young children.

In 1999, Stiller and colleagues [4] examined patterns of care and survival in people with acute leukaemia

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between the ages of 15 and 29 years. They concluded that survival had improved over the 10-year study period in the 15–19 year old group, that survival rates were similar at teaching and non-teaching hospitals, and that entry into trials had a significant beneficial effect on survival. Apart from this article, there is little in the literature discussing the association of risk factors with survival of adolescents and young people from all cancers either in the UK or elsewhere. This study therefore analysed data on all malignancies diagnosed in the age range 15–24 years occurring in Yorkshire in the UK, to determine whether there is a need for a more centralised approach in the management of adolescent cancer services.

2. Patients and methods

The geographical area of Yorkshire, UK has a total population of 3.7 million and encompasses a wide variation of urban and rural environments with accompanying differences in deprivation and population density. A survival analysis was performed on a dataset containing 1097 cases aged 15–24 years, diagnosed in Yorkshire (Fig. 1) between 1 January 1985 and 31 December 1994 and followed-up until 1 January 1998. There were approximately 0.5 million people living in Yorkshire aged 15–24 years in 1991 (The 1991 Census, Crown Copyright, ESRC purchase).

Cases were extracted from a population-based register of malignancies based at the Northern & Yorkshire Cancer Registry and Information Service (NYCRIS). In common with all cancer registries, NYCRIS goes to extensive lengths to ensure completeness of data capture. One of the main strengths of cancer registration is the multiplicity of sources of notification [5]. In the Northern and Yorkshire Region, trained peripatetic clerks from NYCRIS regularly visit all hospitals in the region. Notifications are usually instigated through copies of the pathology forms being forwarded to NYCRIS. Haematological malignancy data are collected through the haematologists. All cases of cancer are flagged at the National Health Service Central Registry in Southport, so that in the case of a non-malignant cause of death, the registry is notified. Copies of death certificates are forwarded to the cancer registry, and therefore we can be confident that details of cases are accurately captured and that death data is fully captured by this system.

The national core contract for cancer registration lays down standards for completeness, accuracy and timeliness in the collection of the minimum dataset [6]. These minimum standards are all being achieved by NYCRIS.

Fig. 1. A map of the former Yorkshire Regional Health Authority by county (populations aged 15–24 years).

Cancers were coded and categorised into the 12 major diagnostic groups detailed in Table 1 according to the ICCC [3], which is based on Birch and Marsden's scheme [7]. The end-point of interest was death from any cause, with date of diagnosis acting as the time-origin. For each diagnostic group/subgroup, the following variables were investigated:

- Gender (male or female).
- Age (in years) at diagnosis (15–19, 20–24).
- Period of diagnosis (1985–1989, 1990–1994).
- County of residence at diagnosis (West Yorkshire, Humberside, North Yorkshire).
- Socio-economic status (Carstairs index [8] from the 1991 census (1991 Census, ESRC Publication Crown Copyright) — based on address at diagnosis).
- Person-based population density (ppd) (1991 Census) divided into thirds.
- Chemotherapy treatment (yes/no) for leukaemias only, was adjusted for in the analysis (result not shown).

Individuals were assigned a deprivation score as a proxy for socio-economic status, based on the validated postcode of their address at diagnosis using the following census variables to calculate the Carstairs index — percentages of unemployed male residents over 16 years, residents in social class 4 and 5, non-car ownership and overcrowding. Each address was linked to its census electoral ward (EW) ($n = 532$) via the central postcode directory. The Carstairs index was categorised into five equal groups of the entire study population, with scores ranging from −4.95 (most affluent) to 17.63 (least affluent).

Ppd at EW level was used as a proxy for urban/rural status: firstly, area-based population density was calculated by dividing the population in each enumeration district (ED) by its area in hectares. Ppd was then obtained by aggregating the population-weighted average of area-based population density in each ED to an EW. This measure more accurately reflects the density at which the average person in any geographical area lives than the classic area-based measure [9]. Ppd was categorised into three groups, and was defined as low (< 35.7 persons/ha), medium (35.7–52.6 persons/ha) and high (> 52.6 persons/ha).

Survival rates were calculated using Kaplan–Meier methods [10]. Initially, ppd was investigated separately using the log-rank test to assess whether survival differed for each diagnostic group. The data were then modelled using Cox's proportional hazards technique [11]. Hazard ratios (HR) and the level of significance (5%) were reported. HR are the ratio of the hazards (probability of dying at time t, having survived to that time) for two different values of a covariate, and can be interpreted in a similar way to relative risks. The level of significance was set at 5%, with a P value of 0.05 or less indicating a statistically significant effect, for compara-

Table 1
Frequency of cancers by diagnostic group and numbers of deaths of children and young adults (15–24 years) diagnosed between 1985 and 1994

ICCC group[a]	Diagnostic group	Cases *n* (%)	Deaths *n* (% of cases)
1–12	All cancers[b]	1097 (100)	289 (26)
1	Leukaemia[b]	84 (8)	53 (63)
1a	Acute lymphoblastic leukaemia	43	24 (56)
1b	Acute myeloid leukaemia	34	22 (65)
1c–1e	Other leukaemias	7	7 (100)
2	Lymphomas	276 (25)	47 (17)
2a	Hodgkin's disease (HD)[b]	206	26 (13)
2b–2e	Non-Hodgkin's lymphoma (NHL)[b]	70	21 (30)
3	Central nervous system (CNS) tumours[b]	129 (12)	43 (33)
4	Sympathetic nervous system tumours	11 (1)	7 (64)
5	Retinoblastoma	0	0
6	Renal tumours	6 (0.5)	2 (33)
7	Hepatic tumours	2 (0.2)	2 (100)
8	Malignant bone tumours	46 (4)	23 (50)
9	Soft-tissue sarcomas	58 (5)	21 (36)
10	Germ cell tumours[b]	162 (15)	27 (17)
11	Carcinomas[b]	295 (27)	60 (20)
11a	Adrenocortical carcinoma	0	0
11b	Thyroid carcinoma	44	0
11c	Nasopharyngeal carcinoma	6	4 (67)
11d	Malignant melanoma	96	14 (15)
11e	Skin carcinoma	52	1 (2)
11f	Other and unspecified carcinomas	97	41 (42)
12	Other and unspecified malignant neoplasms	28 (3)	4 (14)

[a] International Classification of Childhood Cancer [3].

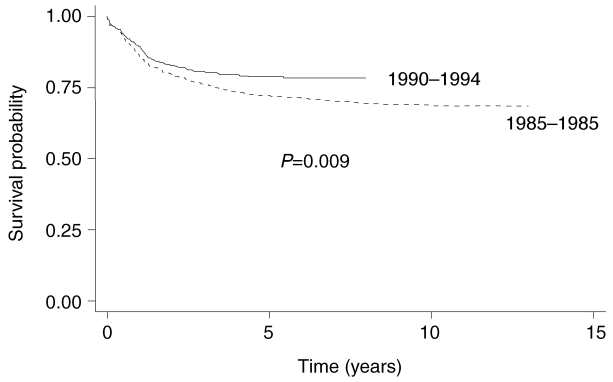

Fig. 2. Kaplan–Meier survival curve by period of diagnosis for all cancers diagnosed between 1985 and 1994.

bility with Stiller and colleague's results [4]. HR for each factor were calculated adjusting for all the other factors, within each diagnostic group. The proportional hazard's assumption appeared to be valid.

3. Results

Table 1 describes the number of cases and deaths for the diagnostic groups, and those which have a sufficient number of deaths to enable a multivariate analysis to be performed. Cases with leukaemia had by far the largest proportion of deaths (almost two-thirds died), whilst a sixth or less of the cases with germ cell tumours and Hodgkin's disease (HD) died. The carcinomas comprised a mixed group of malignancies including melanomas ($n=96$, 33%), thyroid ($n=44$, 15%), skin ($n=52$, 18%) and other ($n=103$, 35%).

Overall survival rates were 87.7, 81.0 and 75.2% at 1 (95% CI: 85.6–89.5), 2 (95% CI: 78.6–83.2) and 5 (95% CI: 72.6–77.7) years, respectively. There was a significant improvement in survival from all cancers combined for adolescents diagnosed in 1990–1994, compared with those diagnosed in 1985–1989 (Fig. 2), with a considerable improvement at 1, 2 and 5 years after diagnosis. This effect was consistent across all three counties.

Table 2 lists the proportion of deaths within each ppd category, by diagnostic group. Although there was no significant evidence of trend in the proportion of deaths across the categories of ppd for any diagnostic group, there was a suggestion that higher ppd was associated with a higher rate of death for all malignancies and carcinoma. (Carcinomas are presented as a single group, as two-thirds of deaths occurred in the 'Other and unspecified' category.)

Table 3 gives the number of cases for each variable and diagnostic group included in the regression analysis. The results of the multivariate regression are presented in Table 4. Between 1985–1989 and 1990–1994, survival improved by 30% overall ($P=0.004$), and this effect was present throughout all diagnostic categories, apart from leukaemias. However, both acute lymphoblastic (ALL) and acute myeloid leukaemia (AML) separately confirmed this finding (data not shown).

The most striking feature of the data is the consistent increased risk of death in Humberside and North Yorkshire compared with West Yorkshire across most of the diagnostic groups. This is not explained by socioeconomic status or population density. The overall significant increase of death of 45% in Humberside ($P=0.009$) and 34% in North Yorkshire is reflected most strongly in adolescents with leukaemia: here, the risk of death in North Yorkshire and Humberside is almost 2.5 times as great. This pattern was also observed for germ cell tumours. A survival curve displaying the significant differences across the three counties of Yorkshire is given in Fig. 3. No significant differences could be demonstrated in the case mix between the three counties in the study.

Further inspection of the data for leukaemia revealed that 90% of patients living in West Yorkshire and North Yorkshire at the time of diagnosis had chemotherapy, compared with only 74% of patients living in Humberside. However, this difference in treatment did not explain the poorer survival in Humberside, because we included a binary variable indicating whether or not chemotherapy was given for leukaemia. Similarly, by including a variable for chemotherapy for all cancers,

Table 2
Trends in survival by person-based population density and diagnostic group

ICCC group[a]	Diagnostic group	Cases	Population density			Test of trend *P* value
			Low	Medium	High	
1–12	All cancers	1097	23.8	25.9	29.4	0.14
1	Leukaemias	84	54.6	77.8	57.1	0.35
2a	Hodgkin's disease (HD)	206	12.1	12.9	12.7	0.99
2b–2e	Non-Hodgkin's lymphoma (NHL)	70	28.6	20.0	40.9	0.26
3	Central nervous system (CNS) tumours	129	29.6	27.9	42.9	0.17
10	Germ cell tumours	162	13.6	19.3	17.4	0.66
11	Carcinomas	295	15.9	21.1	23.2	0.44

[a] International Classification of Childhood Cancer [3].

Table 3
Frequency of cancers by diagnostic group for gender, age and period of diagnosis, county, socio-economic status and population density

Variable	All cancers	Leukaemias	Hodgkin's disease	Non-Hodgkin's lymphoma	CNS[a] tumours	Germ cell tumours	Carcinoma
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
	(*n* = 1097)	(*n* = 84)	(*n* = 206)	(*n* = 70)	(*n* = 129)	(*n* = 162)	(*n* = 295)
Gender							
Male	539 (49)	45 (54)	102 (50)	45 (64)	69 (53)	130 (80)	83 (28)
Female	558 (51)	39 (46)	104 (50)	25 (36)	60 (47)	32 (20)	212 (72)
Age at diagnosis (years)							
15–19	408 (37)	44 (52)	85 (41)	39 (56)	53 (41)	44 (27)	74 (25)
20–24	689 (63)	40 (48)	121 (59)	31 (44)	76 (59)	118 (73)	221 (75)
Period of diagnosis							
1985–1989	575 (52)	43 (51)	110 (53)	38 (54)	66 (51)	88 (54)	144 (49)
1990–1994	522 (48)	41 (49)	96 (47)	32 (46)	63 (49)	74 (46)	151 (51)
County of residence							
West Yorkshire	615 (56)	41 (49)	117 (57)	35 (50)	78 (60)	98 (60)	161 (55)
Humberside	278 (25)	23 (27)	52 (25)	16 (23)	31 (24)	45 (28)	78 (26)
North Yorkshire	204 (19)	20 (24)	37 (18)	19 (27)	20 (16)	19 (12)	56 (19)
Carstairs index							
1 — most affluent	220 (20)	11 (13)	43 (21)	19 (27)	25 (19)	33 (20)	47 (16)
2	216 (20)	16 (19)	40 (19)	12 (17)	33 (26)	28 (17)	61 (21)
3	219 (20)	22 (26)	42 (20)	11 (16)	19 (15)	36 (22)	68 (23)
4	215 (20)	16 (19)	41 (20)	12 (17)	27 (21)	36 (22)	53 (18)
5 — least affluent	227 (21)	19 (23)	40 (19)	16 (23)	25 (19)	29 (18)	66 (22)
Population density							
Low	366 (33)	22 (26)	66 (32)	28 (40)	44 (34)	59 (36)	88 (30)
Medium	367 (33)	27 (32)	85 (41)	20 (29)	43 (33)	57 (35)	95 (32)
High	364 (33)	35 (42)	55 (27)	22 (31)	42 (33)	46 (28)	112 (38)

[a] Central nervous system.

survival differences remained between the counties and population densities.

For socio-economic status and survival, a non-significant dose response was present in the carcinoma group. Those in the least affluent groups were twice as likely to die compared with the most affluent. The numbers of deaths were insufficient to sub-categorise this heterogeneous group of malignancies.

The significant increased risk of death in areas of higher population density ($P = 0.024$) was independent of all other factors, including socio-economic status. The risk associated with population density appeared across all diagnostic groups (apart from HD and high levels of ppd for leukaemia). For leukaemia, including ALL and AML, germ cell tumours and carcinomas areas of medium levels of ppd conferred the highest risk.

Finally, Table 5 shows the number of patients treated by each consultant dealing with patients in this age group over the period of the study. A total of 407 consultants were engaged in the care of adolescents in this age range with cancer. In this 10-year period only 40 consultants (10%) treated 10 or more patients, and almost 75% dealt with less than 5 patients. With the exception of one neurosurgeon, all the consultants treating more than 10 patients were based in the regional cancer centre in West Yorkshire. The data presented in Table 5 was derived from aggregate data held by NYCRIS. We were therefore unable to include a variable in the Cox regression directly related to patient accrual. In a separate analysis, we did produce a model including the size of treating hospital (as registered with NYCRIS): this had no effect on the risk of death, nor did it make any difference to the hazard ratio estimates for the other variables included in the model (data not shown).

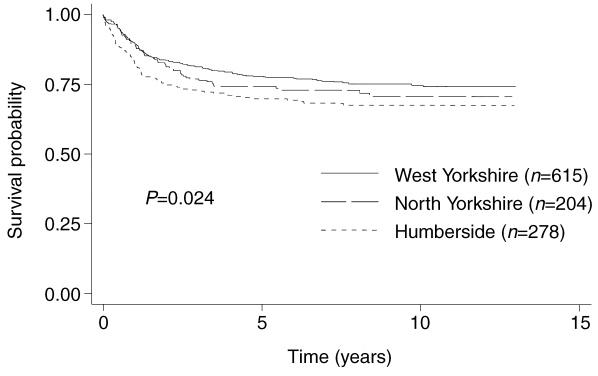

Fig. 3. Kaplan–Meier survival curve by county for all cancers diagnosed between 1985 and 1994.

Table 4
Hazard ratios of dying using Cox regression analysis by diagnostic group for gender, age and period of diagnosis, county, socio-economic status and population density[a]

Variable	All cancers	Leukaemias	Hodgkin's disease	Non-Hodgkin's lymphoma	CNS[b] tumours	Germ cell tumours	Carcinoma
Gender							
Male	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Female	0.91	0.55	1.00	6.19**	1.14	2.16	0.57*
Age at diagnosis (years)							
15–19	1.01	0.45*	1.04	1.32	0.86	0.48	0.64
20–24	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Period of diagnosis							
1985–1989	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1990–1994	0.70**	1.06	0.65	0.30*	0.84	0.46	0.67
County of residence							
West Yorkshire	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Humberside	1.45**	2.43*	0.86	1.49	1.33	5.62**	1.39
North Yorkshire	1.34	2.40*	0.30	1.59	0.76	2.88	1.11
Carstairs index							
1 — most affluent	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2	1.13	1.75	0.85	1.03	0.77	4.33*	1.62
3	0.63*	0.74	0.77	0.25	1.09	0.84	1.15
4	0.79	1.59	0.72	0.36	0.31	3.19	2.28
5 — least affluent	0.94	2.04	0.82	0.37	0.40	1.49	2.06
Population density							
Low	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Medium	1.37	2.21	0.83	1.70	1.28	3.30*	1.15
High	1.60*	0.83	0.92	7.75*	3.21*	1.34	1.08

Significant at $*P < 0.05$, $**P < 0.01$.

[a] Hazard ratios are mutually adjusted for all other factors (i.e. gender, age, period, county, Carstairs index, population density, and chemotherapy treatment (Yes/No) for leukaemia).

[b] Central nervous system.

4. Discussion

There have been a number of attempts to produce a standard definition of adolescence. It is inevitably an indistinct concept and varies from individual to individual. There is no universally accepted age limit for adolescents and most would agree that no individual could be considered an adolescent outside the age range of 10–25 years, but within that age range, many different age criteria are used. The World Health Organization defines adolescents as being aged between 10 and 19 years [12]. Other studies on adolescents, some of which are described later, consider a different age range. For example, Jamison [13], in his study of the psychological impact of cancer in 1985, used the age range 12–18 years. Enskär and colleagues [14], in a study which looked at 10 adolescents with cancer, used the age range 13–20 years.

Table 5
Number of consultants treating individual patients aged 15–24 years in the Yorkshire Region between 1985 and 1994

Patients treated	Number of consultants	%
1	159	39.1
2–4	139	34.2
5–9	69	17
10–19	24	5.9
20–29	5	1.2
30+	11	2.7
All	407	100.0

The differing types of cancer combined with the specific needs of adolescence mean there is currently a debate on how adolescent cancer should be managed. This debate centres around whether it should be centralised in an adolescent cancer unit, as set out in the Calman-Hine Report [15], or as a less centralised model which, for example, would avoid the disadvantages for patients living in rural areas [16]. Currently, there are around 20 adolescent cancer units in the UK. The proposal to create an adolescent cancer unit in Yorkshire was the stimulus for this review.

The strength of this study is that it has examined data based on an appropriate classification scheme. Making direct comparisons with other work is difficult because of the inconsistent use of age groups. However, this study has concentrated on the 15–24 year olds, a group on which little has been reported in the past. The

improvement in survival over time is not a surprising finding given the improvements in treatment over this period, particularly in the leukaemias, and has been reported before for 15–19 year olds in the UK [4] and US [17]. This is also a similar finding to that of Pollán and colleagues [18] who reported on trends in mortality in under 20 year olds in the population of Spain between 1956 and 1990. They looked at the mortality from seven sites and reported that overall mortality had declined over this period. This decline had begun to occur at the beginning of the 1970s, and the authors concluded that the decline (where it could be demonstrated) was due to better treatment and improved facilities.

Males have been noted in previous studies to have poorer survival than females [19–22] and this is consistent with the results of the current investigation. No differences were found in the age–sex standardised incidence of cancer in these age groups, with the exception of a small significant excess in Humberside of epithelial tumours. However, this excess was small (50.6 cases per 100 000 compared with 45.0) and only related to 80 cases over the 10-year period with 19 deaths and we conclude this small, but significant, excess incidence could not account for the survival differences, which have been demonstrated.

The differences between the geographical areas of Yorkshire are notable. Attempts were made to examine the hospital of treatment in the cancer registry datasets, but use of hospital of treatment filed in the dataset was unreliable, and on discussion with some of the clinicians concerned it was apparent that assigning a single hospital to a patient was inappropriate, as many of the patients had been treated in a number of units. Thus it was not possible to be certain where the patient received the significant part of their treatment. Given that previous studies have indicated that cancer is both more prevalent and has a poorer outcome in those areas with lower socio-economic status [23], the findings presented here are counter intuitive in that West Yorkshire and Humberside are less affluent than North Yorkshire.

The findings of these analyses show that there is a statistically significant difference in outcome between the three geographical areas. Geographical differences in survival in Yorkshire could be due to one of three explanations. Could these differences have occurred by chance? This cannot be totally excluded, although the size of the differences observed would suggest otherwise. Alternatively, the statistical modelling failed to take into account hospital treatment differences across the region. The observed difference in survival may then have disappeared in the multivariate analysis.

Within these data, dose–response relationships might have been expected within the individual diagnostic categories. However, the small numbers involved in each of these groupings, even over a 10-year period, make it difficult to draw such conclusions. Even extending the study period is unlikely to be helpful, as the extended study period is likely to encompass considerable variation in treatment and management.

The second possibility is that the epidemiology of cancer differs significantly across the North of England and that a systematic pattern of presentation may have occurred whereby more or less advanced cases appear in one place or another. There was no evidence to suggest that this might be a possibility, but clinicians in the area have suggested that more aggressive malignancies are more common in Humberside than elsewhere. Further work needs to be done to explore potential differences in case-mix, but this is likely to require a new study rather than utilising existing data collection systems.

The third possibility is that the differences in outcome are related to treatment and/or the organisation of clinical care. All the consultants treating more than 30 patients (an average of 3 per year) were based in a cancer centre. This raises the question of volume-related outcomes which have been alluded to in other studies. It also needs to be emphasised that over this period there have been considerable changes in clinical practice, and, for example, in Humberside particularly, many of the consultants previously involved with the clinical care of adolescents have retired. Although it is difficult to resolve the exact reason for our findings, we should emphasise that the case data is retrospective in nature, comprising malignancies diagnosed between 1985 and 1994.

There are no data available at the present time to make comparisons about the current service. Should this study be used as evidence for centralisation of all adolescent cancer care? The arguments that services away from the centre have changed are powerful ones. However, the difficulty in demonstrating that the current services have very different outcomes to that previously demonstrated is that to do so will involve data collection for a further 5–10 years before it is possible to demonstrate any differences.

Population density analysis suggests that those living in more dense areas are more likely to have a poorer outcome, after accounting for socio-economic status. This is unlikely to be explained by ethnicity, because recent studies have shown there to be no difference in survival between White and Asian children [24,25], and contradicts findings from a study in Scotland which found that patients living in rural areas with cancer had a poorer prognosis [26]. Other plausible explanations are not obvious, and a lack of Asian numbers in the data prevented further analysis.

The Calman-Hine Report [15] published in 1995 recommended that for England and Wales the ways in which adolescents with cancer were managed needed to be reviewed and went on to recommend that because of

special medical and psychological problems of adolescents, they require ''specialised care in the cancer centre''. It stated that ''the development of centres for the care of adolescents with cancer is less complete'' and suggested refurbishment or development of facilities for such patients is required. The National Cancer Guidance series of reports published by the NHS in England is due to publish a document on haematological malignancies in 2001 (R.A. Haward, NYCRIS). Similar to other guidances, for example those for breast cancers [27] and gynaecological cancers [28], this will set out minimum standards for the organisation of care for those with particular cancers. As a large proportion of these malignancies are suffered by adolescents, the impact of this guidance in the management of adolescents with cancer will be important.

The National Plan for Cancer [29], which applies to England, contains standards for waiting times for patients with leukaemia. As far as adolescents are concerned, most of these are currently being met, and the National Plan should have a positive effect on adolescent cancer services, not only by setting minimum standards for waiting times, but also through the significant planned investment in staff and facilities for all patients with cancer.

What does this report contribute to the debate about the creation of a more centralised approach to the management of adolescent cancers? The geographical differences could be interpreted as being supportive of the argument to further centralise treatment. However, the findings could indicate the need to invest more in locations away from the centre to improve the initial diagnosis and referral into the major centre. Further work is clearly required to delineate the benefits of a more centralised approach. Although survival is probably the most important factor in the pattern of management of adolescent cancer, other factors may need to be taken into account, such as the environment in which young people are managed [30]. Adolescents are a group with special emotional needs, often at important times in their education. Adolescent cancer units could be important in providing more suitable environments for the management of these young people.

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References

1. Office for National Statistics. *DVS3.L*. London, 1993.
2. Fritschi L, Coates M, McCredie M. Incidence of cancer among New South Wales adolescents: which classification scheme describes adolescent cancers better? *Int J Cancer* 1995, **60**, 355–360.
3. Kramárová E, Stiller CA, Ferlay J, *et al*. *International Classification of Childhood Cancer*. IARC technical report No. 29. Lyon, IARC, 1996.
4. Stiller CA, Benjamin S, Cartwright RA, *et al*. Pattern of care and survival for adolescents and young adults with acute leukaemia — a population based study. *Br J Cancer* 1999, **79**, 658–665.
5. Forman D, Rider L. *Cancer in Yorkshire; Cancer Statistics 1989–1993*. Yorkshire, Yorkshire Cancer Organisation, 1996.
6. NHS Executive. *Core Contract for Commissioning Cancer Registration EL(96)7*. London, 1996.
7. Birch JM, Marsden HB. A classification system for childhood cancer. *Int J Cancer* 1987, **40**, 620–624.
8. Carstairs V, Morris R. *Deprivation and Health in Scotland*. Aberdeen, Aberdeen University Press, 1991.
9. Dorling D, Atkins D. *Population Density, Change and Concentration in Great Britain 1971, 1981 and 1991. Studies on Medical and Population Subjects, No. 58*. London, HMSO, 1995.
10. Kaplan ES, Meier P. Nonparametric estimation from incomplete observations. *J Am Stat Assoc* 1958, **53**, 457–481.
11. Cox DR. Regression models and life tables. *J R Stat Soc B* 1972, **34**, 187–220.
12. Williams H. Health and illness in adolescents: a national overview. In Macfarlane A, ed. *Adolescent Medicine*, vol. 1. London, Royal College of Physicians, 1996, 3–8.
13. Jamison RN, Lewis S, Burish TG. Psychological impact of cancer on adolescents: self-image, locus of control, perception of illness and knowledge of cancer. *J Chron Dis* 1986, **39**, 609–617.
14. Enskär K, Carlsson M, Golsäter M, Hamrin E. Symptom distress and life situation in adolescents with cancer. *Cancer Nurs* 1997, **20**, 23–33.
15. Expert Advisory Group on Cancer. *A Policy Framework for the Commissioning of Cancer Services*. London, Department of Health and the Welsh Office, 1995.
16. Baird AG, Donnelly CM, Miscampell NT, Wemyss HD. Centralisation of cancer services in rural areas has disadvantages. *BMJ* 2000, **320**, 717.
17. Smith MA, Gurney JG, Gloeckler Ries LA. *Cancer Among Adolescents 15–19 Years Old. Cancer Incidence and Survival among Children and Adolescents: United States SEER Program 1975–1995, National Cancer Institute, SEER Program*. NIH Publication No. 99-4649. Bethesda MD; 1999.
18. Pollán M, López-Abente G, Ruiz-Tovar M, Martínez de Aragón MV. Childhood and adolescent cancer in Spain: mortality time trends 1956–1990. *Eur J Cancer* 1995, **31A**, 1811–1821.
19. Nicholson HS, Fears TR, Byrne J. Death during adulthood in survivors of childhood and adolescent cancer. *Cancer* 1994, **73**, 3094–3102.
20. Green DM, Zevon MA, Reese PA, *et al*. Second malignant tumors following treatment during childhood and adolescence for cancer. *Med Pediatr Oncol* 1994, **22**, 1–10.
21. Adami HO, Glimelius B, Sparen P, Holmberg L, Krusemo UB, Ponten J. Trends in childhood and adolescent cancer survival in Sweden 1960 through 1984. *Acta Oncol* 1992, **31**, 1–10.
22. Carmen Martos M. Cancer among teenagers in Denmark 1943–1987. *Int J Cancer* 1993, **55**, 57–62.
23. Coleman M, Babb P, Damiecki P, *et al*. *Cancer Survival and Trends in England and Wales 1971–1995*. London, The Stationery Office, 1999.
24. McKinney PA, Feltbower RG, Parslow RC, *et al*. Survival from childhood cancer in Yorkshire, UK: effect of ethnicity and socioeconomic status. *Eur J Cancer* 1999, **35**, 1816–1823.

25. Powell JE, Mendez E, Parkes SE, Mann JR. Factors affecting survival in White and Asian children with acute lymphoblastic leukaemia. *Br J Cancer* 2000, **82**, 1568–1570.
26. Campbell NC, Elliott AM, Sharp L, Ritchie LD, Cassidy J, Little J. Rural factors and survival from cancer: analysis of Scottish cancer registrations. *Br J Cancer* 2000, **82**, 1863–1866.
27. NHS Executive. *Improving Outcomes in Breast Cancer*. London, 1996.
28. NHS Executive. *Improving Outcomes in Gynaecological Cancers*. London, 1999.
29. Department of Health. *The NHS Cancer Plan: A Plan for Investment, a Plan for Reform*. London, 2000.
30. Lewis IJ. Cancer in adolescence. *Br Med Bull* 1996, **52**, 887–897.