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Epidemiology of leukaemia and lymphoma in children and young adults from the north of England, 1990–2002

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ABSTRACT

Aim: We aimed to describe and contrast the epidemiology of haematological malignancies among 0–14 and 15–24-year-olds in northern England from 1990 to 2002 and compare clinical trial entry by age group.

Patients and methods: Incidence rates were examined by age, sex and period of diagnosis and differences were tested using Poisson regression. Differences and trends in survival were assessed using Cox regression.

Results: 1680 subjects were included comprising 948 leukaemias and 732 lymphomas. Incidence rates for acute lymphoblastic leukaemia were significantly higher for 0–14 compared to 15–24-year-olds, whilst Hodgkin lymphoma showed the reverse. No significant changes in incidence were observed. 60% of leukaemia patients aged 15–24 years entered trials compared to 92% of 0–14-year-olds. Survival rates were significantly lower and improved less markedly over time for 15–24 compared to 0–14-year-olds, particularly for leukaemia.

Conclusions: Trial accrual rates need to be improved amongst 15–24-year-olds and a more structured follow-up approach adopted for this unique population.

1. Introduction

Patterns describing incidence and survival rates for childhood (ages 0–14 years) leukaemia and lymphoma have been well documented in most of the world over the last 3 decades.[1–5] Recent reports indicate that average annual age-standardised incidence rates are 25–35 and 10–20 per million person-years for those diagnosed with childhood leukaemia and lymphoma aged under 15 years, equivalent to approximately 450 and 150 newly diagnosed cases in the United Kingdom (UK) each year.[6]

Leukaemia and lymphoma comprise around 40–45% of all childhood malignancies in those aged 0–14 years. Acute lymphoblastic leukaemia (ALL) is the most common subtype of leukaemia in children under 15 years of age accounting for 75–80% of leukaemias and exhibits the well described peak

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in incidence between the ages of 1 and 4 across most developed countries.[7] Acute myeloid leukaemia (AML) represents around 15–17% of childhood leukaemias.[7] There is a 20% male excess in incidence across most leukaemia subtypes seen in children.[6]

Childhood lymphoma, although less common than leukaemia, also exhibits a more pronounced male excess in incidence, being twice as common under the age of 15 in boys than in girls.[1] Hodgkin lymphoma (HL) increases gradually with age in children aged under 15, whilst non-Hodgkin lymphoma (NHL) remains fairly uniform from the age of 3 upwards.[6] Amongst 15–24-year-olds, leukaemia and lymphoma account for about 1 in 3 malignancies. Lymphoma is the most common type of cancer representing around 20% of all diagnoses in this age group, with leukaemia accounting for a further 10%.[8,9]

Most long-term epidemiological cohort analyses have reported increased incidence rates for leukaemia and lymphoma in young people over the last 20–30 years. For example, Cotterill and colleagues[10] showed that age-standardised rates for haematological malignancies increased by 3.6 and 5.0 per million per year for 0–14 and 15–24-year-olds, respectively, between 1968 and 1995 in the north of England, whilst data from the Southern Netherlands showed a 3% annual rise between 1973 and 1999 for 0–24-year-olds.[11]

Survival rates among children and young adults have increased substantially since the 1970s throughout the western world, including the United States (US),[4] the UK[9,10] and the rest of Europe.[12] Five-year survival rates have recently exceeded 80% and 90% for childhood leukaemia and HL.[6]

In summary, information on the incidence and survival rates of childhood leukaemia and lymphoma is extremely well documented. The aim of the present study was to enhance knowledge available on the occurrence and survival of leukaemia and lymphoma, focusing on those aged 15–24 years whilst drawing comparisons with those aged 0–14 years through the exploitation of data from two geographically adjacent high quality population-based specialist cancer registers in the north of England. Two further objectives were to (i) document and assess the effect of trial entry on survival across the 0–24-year-old age range and (ii) examine whether the reported association between socio-economic status and the occurrence of childhood leukaemia[7,13,14] and lymphoma[14] was also present amongst haematological tumours diagnosed between the ages of 15–24 years.

2. Patients and methods

2.1. Patients

Information on patients diagnosed with leukaemia or lymphoma under the age of 25 years between 1990 and 2002 was extracted from two adjacent specialist tumour registers in the north of England: the Yorkshire Specialist Register of Cancer in Children and Young People (YSRCCYP)[15] and the Northern Region Young Person's Malignant Disease Register (NRYPMDR).[9] The two population-based registers have accrued cases who were resident in the areas of the former Northern and Yorkshire Regional Health Authorities, excluding barrow-in-furness in South Cumbria, since 1968 and 1974, respectively (2001 combined census population approximately 2,250,000 under 25 years). Both completeness rates and the proportion with histologically verified tumours are extremely high.[10,15] External cross-checks were undertaken with national clinical trials units in Oxford (ALL), Birmingham (AML) and London (lymphoma), along with the UK Children's Cancer and Leukaemia Group (previously the UK Children's Cancer Study Group, which co-ordinated national trials for ALL in infants and lymphoma in children) to ensure completeness of trial entry data. Regional trials which were open to Northern Region patients aged 0–24 years included NE ALL III–VI, Scotland and Newcastle Lymphoma Group (SNLG) HD3, and SNLG HIGH GRADE NHL V–V(a). All cases were followed-up until 31st December 2007 to allow each survivor to contribute at least 5 person-years to the survival analysis.

Cancer diagnoses were categorised according to the International Classification of Childhood Cancer (ICCC)[16] based on ICD-O-2 morphology and site codes and classified as acute lymphoid leukaemia (ICCC group Ia) which include ALL, acute non-lymphocytic leukaemia (Ib) which include AML, other leukaemia (Ic–Ie), HL (IIa) and NHL (IIb–IIe).

2.2. Statistical analysis

Age-standardised incidence rates were calculated using the world standard population. Differences by period of diagnosis, age at diagnosis, sex, region (Yorkshire versus Northern) and deprivation were assessed using Poisson regression modelling. Deprivation was measured using the area-based Townsend index[17] derived from the UK census based on the levels of unemployment, car ownership, housing tenure and household overcrowding, and linked to an electoral ward derived from the address at diagnosis. Cox regression was used to evaluate survival trends and determine if survival differed according to the list of covariates above together with trial entry. Deprivation was included in the regression model as a continuous variable to minimise the loss of information, statistical power and precision due to categorisation.[18] Hazard ratios (HRs) and 95% confidence limits are presented. All statistical analyses were performed using Stata version 10.

3. Results

3.1. Incidence rates

1680 subjects were included in the analysis in total, comprising 948 leukaemias and 732 lymphomas. Table 1 shows the breakdown of numbers and incidence rates (per million person-years) by diagnostic group, sex and age at diagnosis.

Incidence rates for ALL were higher for 0–14-year-olds (36.4; 95% confidence interval (CI) 33.4–39.4) compared to 15–24-year-olds (9.6; 95% CI 7.8–11.4). HL was the most common haematological malignancy amongst 15–24-year-olds (31.5). Females exhibited significantly lower rates than males overall for ALL (23.0, 95% CI 20.3–25.7 versus 30.7, 95% CI 27.6–33.7) and HL (12.0, 10.3–13.7 versus 17.3, 15.2–19.3), although this pattern was not evident for those aged 10–14 years with leukaemia. There was also a smaller male excess of HL at age

Table 1 – Incidence rates per million per year and the number of cases for haematological cancers diagnosed aged 0–24 years in the former Yorkshire and Northern Regional Health Authorities, 1990–2002

ICCC Group		Leukaemias	Acute lymphoid leukaemia	Acute myeloid leukaemia	Other leukaemia	Lymphomas	Hodgkin lymphoma	Non-Hodgkin lymphoma
		I	Ia	Ib	Ic–Ie	II	IIa	IIb–IIe
Age	*Gender*	*Rate (N)*	*Rate (N)*	*Rate (N)*	*Rate (N)*	*Rate (N)*	*Rate (N)*	*Rate (N)*
0–4	Male	77.8 (216)	65.6 (182)	9.0 (25)	3.3 (9)	9.4 (26)	1.8 (5)	7.6 (21)
	Female	58.1 (154)	46.5 (123)	11.0 (29)	0.8 (2)	10.2 (27)	1.1 (3)	9.1 (24)
5–9	Male	42.4 (123)	34.5 (100)	5.2 (15)	2.7 (8)	20.0 (58)	8.7 (25)	11.3 (33)
	Female	32.8 (91)	26.4 (73)	5.0 (14)	1.4 (4)	6.2 (17)	0.7 (2)	5.4 (15)
10–14	Male	22.2 (64)	16.3 (47)	4.6 (13)	1.4 (4)	26.5 (76)	15.9 (46)	10.6 (30)
	Female	23.1 (63)	17.2 (47)	4.8 (13)	1.1 (3)	13.2 (39)	6.7 (19)	7.3 (20)
15–19	Male	23.2 (65)	12.8 (36)	8.6 (24)	1.8 (5)	38.2 (107)	26.2 (73)	12.1 (34)
	Female	18.7 (50)	10.1 (27)	7.9 (21)	0.7 (2)	29.5 (84)	23.7 (63)	8.0 (21)
20–24	Male	24.6 (71)	10.2 (29)	9.3 (27)	5.2 (15)	58.6 (170)	42.7 (125)	15.8 (45)
	Female	17.9 (51)	4.9 (14)	10.6 (30)	2.4 (7)	44.2 (128)	34.7 (100)	9.8 (28)
Total (0–24)	Male	40.8 (539)	30.7 (395)	7.4 (105)	2.8 (41)	28.3 (437)	17.3 (274)	11.1 (163)
	Female	32.2 (409)	23.0 (284)	7.9 (107)	1.2 (18)	19.3 (295)	12.0 (187)	7.9 (108)
0–14	Total	45.1 (711)	36.4 (572)	6.8 (109)	1.8 (30)	14.0 (241)	5.5 (100)	8.5 (143)
15–24	Total	21.1 (237)	9.6 (106)	9.0 (102)	2.5 (29)	42.0 (491)	31.5 (361)	11.3 (128)
ASR	Total	36.6 (948)	26.9 (678)	7.6 (211)	2.1 (59)	23.9 (732)	14.7 (461)	9.5 (271)

ASR: age-standardised incidence rate using the world standard population; N: number of subjects; and ICCC: International Classification of Childhood Cancer.

15–19 compared to 0–14 and 20–24-year-olds, and a non-significant female excess for NHL among 0–4-year-olds.

No significant changes in incidence rates occurred during the study period either for children aged 0–14 years or young adults aged 15–24 years. No temporal variation in incidence was observed in either the Yorkshire or the Northern Regions. There was no association between the rates of leukaemia or lymphoma and the area-based levels of deprivation.

3.2. *Trial accrual rates*

Table 2 summarises the proportion of patients who were entered into a regional or national clinical trial following their initial diagnosis, stratified according to region and age group at diagnosis. There was a clear discrepancy between the proportion of patients entering trials by age at diagnosis: those aged 0–14 years had a much greater likelihood of entering a trial (86% overall) compared to their 15–24-year-old counter-

Table 2 – Proportion entered into a clinical trial following initial diagnosis by region, diagnostic group and age at diagnosis for cancers diagnosed aged 0–24 years in the former Yorkshire and Northern Regional Health Authorities, 1990–2002

Diagnostic Group	Proportion entered into a clinical trial							
	0–14		15–19		20–24		15–24	
	Northern	Yorkshire	Northern	Yorkshire	Northern	Yorkshire	Northern	Yorkshire
Leukaemias	88% (278/315)	95% (375/396)	60% (34/57)	64% (37/58)	56% (35/63)	61% (36/59)	58% (69/120)	62% (73/117)
Acute lymphoid leukaemia	93% (241/258)	97% (305/314)	66% (21/32)	55% (17/31)	69% (20/29)	43% (6/14)	67% (41/61)	50% (23/45)
Acute myeloid leukaemia	83% (33/40)	87% (60/69)	59% (13/22)	83% (19/23)	65% (15/23)	85% (29/34)	62% (28/45)	82% (48/57)
Other leukaemia	24% (4/17)	77% (10/13)	0% (0/3)	25% (1/4)	0% (0/11)	9% (1/11)	0% (0/14)	13% (2/15)
Lymphomas	67% (70/105)	72% (99/138)	19% (14/73)	27% (32/118)	5% (7/131)	13% (21/167)	10% (21/204)	19% (53/285)
Hodgkin lymphoma	70% (31/44)	66% (37/56)	9% (5/53)	20% (17/83)	6% (6/97)	15% (19/128)	7% (11/150)	17% (36/211)
Non-Hodgkin lymphoma	64% (39/61)	76% (62/82)	45% (9/20)	43% (15/35)	3% (1/34)	5% (2/39)	19% (10/54)	23% (17/74)
All cancers	83% (348/420)	89% (474/534)	37% (48/130)	39% (69/176)	22% (42/194)	25% (57/226)	28% (90/324)	31% (126/402)

parts (30%). 60% of all leukaemia patients entered into trials aged 15–24 years compared to 92% of 0–14-year-olds on average across the study period. Furthermore, a very small percentage of patients diagnosed with lymphoma aged 15–24 years entered into a trial (typically 10–20% of the total number diagnosed) compared to 70% for those aged 0–14 years. The only diagnostic group where we observed a large difference in trial accrual between 15–19 and 20–24-year-olds was for NHL, with around 45% of individuals enrolled in the younger age group compared to only 4% aged 20–24 years.

3.3. *Survival*

Excluding NHL, survival rates were significantly poorer for 15–24s compared to 0–14-year-olds (Fig. 1a–d; Table 3), with the separation in survival most marked and statistically significant for leukaemia (HR = 2.7; 95% CI 2.1–3.5), especially ALL (HR = 3.2; 95% CI 2.2–4.5). Cox regression modelling (Table 3) showed that for all haematological cancers the combined risk of death was significantly higher among 15–24-year-olds compared to those aged 0–14 years (HR = 1.7; 1.3–2.1). Furthermore, survival rates for ALL showed a significant improvement over time for 0–14-year-olds ($P_{trend} = 0.004$) in contrast to very little change for 15–24-year-olds ($P_{trend} = 0.343$) (Fig. 2a and b), although a formal test for interaction suggested there was no significant difference in the rate of improvement in survival between the two age groups for leukaemia, lymphoma or all cancers combined.

Females with NHL showed a significant increased risk of death compared to males (HR = 1.8; 1.1–2.7). No significant differences in survival were seen by deprivation or region apart from AML, where a reduced risk of death was observed in the Northern Region (HR = 0.4; 0.3–0.7). Trial entry suggested that those treated on an open protocol had a modestly reduced risk of death for leukaemia (HR = 0.84, 0.62–1.13), compared to those not entered into a trial, although this was only significant for AML (HR = 0.55, 0.32–0.95). This effect was most pronounced among 0–14s where a significant reduced risk of death was observed for all leukaemias and AML.

All Cox regression models met the underlying assumption of proportional hazards following the inspection of Schoenfeld residuals.

4. Discussion

Set against a background of stable incidence rates of haematological malignancies in the north of England between 1990 and 2002, we report significant differences in the survival rates for leukaemia and lymphoma by age group. Survival was consistently lower and improved less quickly for 15–24s compared to 0–14-year-olds across virtually all diagnostic groups. The threefold increased risk of death for individuals

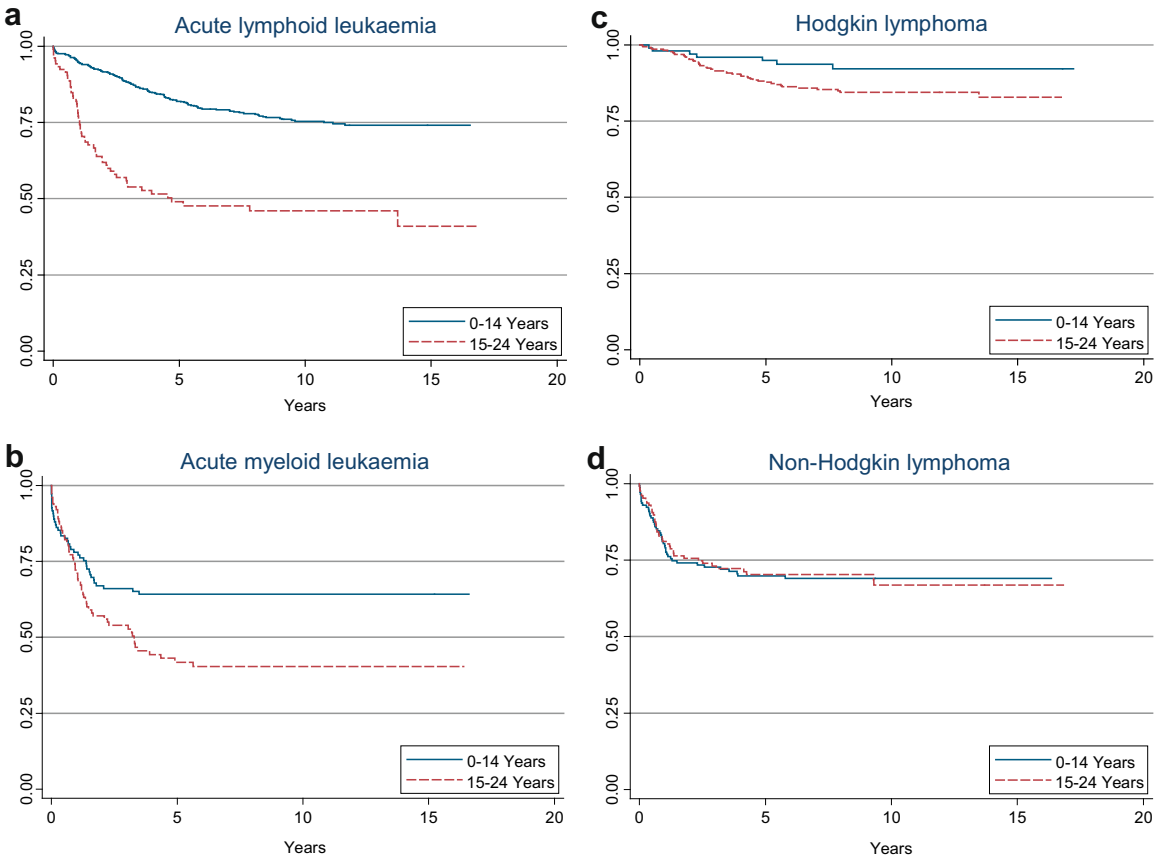

Fig. 1 – Kaplan–Meier survival plots by age at diagnosis for (a) acute lymphoid leukaemia, (b) acute myeloid leukaemia, (c) Hodgkin lymphoma and (d) non-Hodgkin lymphoma diagnosed in the former Yorkshire and Northern Regional Health Authorities, 1990–2002.

Table 3 – Hazard ratio estimates (95% CI) from Cox regression for haematological cancers diagnosed aged 0–24 years in the former Yorkshire and Northern Regional Health Authorities, 1990–2002

	All cancers	Leukaemias	ALL[b]	AML[b]	Lymphomas	Hodgkin lymphoma	Non-Hodgkin lymphoma
Age							
15–24 versus 0–14	1.65 (1.31–2.08)	2.74 (2.13–3.54)	3.17 (2.23–4.52)	1.84 (1.21–2.78)	0.77 (0.50–1.18)	2.21 (0.90–5.45)	0.83 (0.50–1.37)
Sex							
Female versus male	1.03 (0.85–1.24)	0.85 (0.68–1.07)	0.75 (0.56–1.01)	1.06 (0.70–1.58)	1.54 (1.10–2.16)	1.27 (0.75–2.15)	1.76 (1.13–2.73)
Period of diagnosis							
1994–1997 versus 1990–1993	1.01 (0.81–1.27)	0.93 (0.71–1.22)	1.08 (0.77–1.52)	0.82 (0.49–1.39)	1.08 (0.72–1.62)	1.07 (0.56–2.05)	1.05 (0.62–1.79)
1998–2002 versus 1990–1993	0.77 (0.61–0.96)	0.73 (0.56–0.97)	0.71 (0.49–1.02)	0.86 (0.53–1.39)	0.81 (0.54–1.21)	1.09 (0.56-2.12)	0.58 (0.34–0.98)
Region							
Northern versus Yorkshire	1.06 (0.88–1.28)	0.87 (0.69–1.09)	1.17 (0.88–1.57)	0.42 (0.26–0.67)	1.19 (0.85–1.66)	1.07 (0.62–1.83)	1.39 (0.90–2.15)
Trial entry							
Yes versus No	1.06(0.87–1.29)[a]	0.84 (0.62–1.13)	0.92 (0.58–1.44)	0.55 (0.32–0.95)	0.95 (0.62–1.45)	1.10 (0.52–2.29)	0.68 (0.41–1.13)
Deprivation							
Townsend index	1.02 (0.99–1.05)	1.01 (0.98–1.04)	1.03 (0.99–1.07)	0.97 (0.91–1.03)	1.00 (0.95–1.05)	1.00 (0.93–1.08)	0.98 (0.92–1.05)

a Parameter estimate for all cancers is reported without adjustment for age at diagnosis due to high collinearity with trial entry.
b ALL: acute lymphoid leukaemia and AML: acute myeloid leukaemia.

aged 15–24 years with leukaemia compared to their 0–14 counterparts, an observation seen in other European countries among 15–19-year-olds,[12] is particularly concerning and warrants further investigation. Furthermore, the study is the first UK population-based analysis to compare clinical trial uptake between 15–24 and 0–14-year-olds, where we highlight the lack of availability and entry into trial protocols for individuals in the older age group.

Reasons that might explain the observed difference in survival by age group, such as the period of diagnosis, sex, deprivation and trial entry were adjusted for in the analysis by Cox regression modelling. Ethnicity was not corrected for as this was highly correlated with deprivation and has been shown to be unrelated to survival rates in the previous epidemiological analyses.[19] Other explanatory factors may be related to follow-up practices: for example, few 15–24-year-olds receive the same level of follow-up as those diagnosed under the age of 15. Psychosocial support may also be less well developed among 15–24s to help these young people cope with their illness,[20] thereby affecting compliance with self-administered chemotherapy. In addition, personal and professional delay in diagnosis may be more prevalent among 15–24-year-olds compared to 0–14s,[21–23] although evidence for this is still relatively scarce.[20] Teenagers and young adults (TYA) also generally tolerate chemotherapy less well than children and are less likely to receive their full protocol dosage as a result. The risk of treatment-related mortality may also have contributed to poorer survival chances seen in the older TYA age group, for example through the increasing prevalence of avascular necrosis seen among 15–19-year-olds with ALL.[24] Older patients aged 15–24 years with ALL were also more likely to have been treated on adult rather than on paediatric protocols. This may have explained some of the observed differences in survival by age, following evidence that TYA patients have less favourable outcomes on adult trials compared to paediatric protocols.[25–28]

A key element relating to clinical outcome in these age groups is likely to be the undoubted biological differences seen in ALL and AML. These differences are most obviously seen in the different cytogenetic subgroups found in the acute leukaemias between children and adults.[29] Findings from large numbers of patients entered into the UK ALL XII study have shown that there are increasing numbers of individuals in several poor risk cytogenetic categories with increasing age.[29] Such patients have reduced chemocurability and this may explain our observed findings. Similarly in HL, there are biological differences between children and young adults with regard to the presence of clonal EB virus in the Reed Sternberg tumour cells. In childhood, they are more likely to be EBV positive[30] and this phenotype relates to favourable outcome. In young adults, EBV positivity falls and the nodular sclerosing subtype increases[31] often associated with bulky disease, indicating a biological heterogeneity associated with reduced cure rates, which are consistent with our data.

These findings are reported from one of the few population-based epidemiological analyses of haematological cancers covering the childhood, teenage and young adult age range. Leukaemias and lymphomas represent two of the larg-

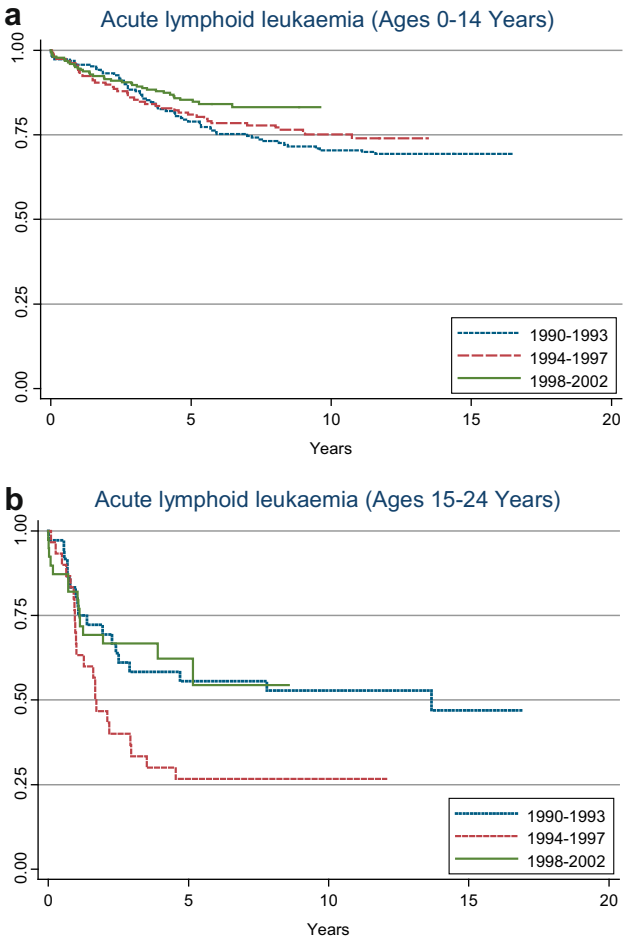

Fig. 2 – Kaplan–Meier survival plots for acute lymphoid leukaemia by period and age at diagnosis in the former Yorkshire and Northern Regional Health Authorities, 1990–2002: (a) 0–14 years and (b) 15–24 years.

est diagnostic groups which span the 0–14 and 15–24-year-age groups. A common limitation of other cancer epidemiological investigations focusing on incidence and survival trends in young people is that many national and international studies in the past have been restricted to paediatric patients aged 0–14 years,[2,3,5,32,33] 0–19[34] or TYA age groups (13–24 years).[8,35] This artefactual cut-off may therefore mask some important epidemiological and aetiological factors, which may be common to both age groups.[36]

A novel aim of the study was to examine the prevalence and effect of trial entry on survival, comparing 0–14 and 15–24-year-olds given the lack of population-based evidence in this age group. Although we acknowledge that data on trial entry among 15–24-year-olds may be slightly less complete than that for 0–14-year-olds, since the latter group receive centralised care in dedicated paediatric oncology units, we undertook a validation exercise with national trials organisations to ensure these data were as accurate as possible.

Trial entry among patients with leukaemia aged 15–24 years (60%) was substantially lower than that for 0–14-year-olds (92%), although much higher than earlier population-based case series for 15–29-year-olds with leukaemia diagnosed between 1984 and 1994[37] where trial entry was reported to be around 38% for both ALL and AML. In a follow-up study linked to the cohort study by Stiller and colleagues,[37] questionnaires were sent to hospitals identified as treating leukaemic patients aged 15–29 years to ascertain reasons for inclusion/exclusion of patients from available MRC trials in the previous 5 years.[38] 82% of haematologists stated they entered patients 'always/when possible' for AML and 76% for ALL. Actual trial entries from these hospitals were 46% and 36%, respectively. This demonstrated the difference of 'intent' towards trial entry and actual trial entry. The common reasons given for non-entry to national leukaemia trials were clinician preference for one arm of the study, an alternative regional protocol, concern of workload/lack of support and ethical approval paperwork. There was no marked difference in accrual rates between 15–19 and 20–24-year-olds except for a much higher proportion of younger TYA patients entered onto trials with NHL (45%), although this still fell short of the proportion attained for 0–14-year-olds (70%).

The paucity of national trials available to those aged over 15, particularly in HL and NHL for 20–24-year-olds, in contrast to 0–14-year-olds during the study period may explain part of this discrepancy, for example, through the existence of leukaemia protocols such as UKALL XI (1990–97), UKALL XII (1997–2002), AML 10 (1988–1995), AML 12 (1996–2001) and AML 15 (2002 onwards). Although some lymphoma trials were open between 1990 and 2002 (e.g. HD 1992 01, SNLG HD3, NHL 1996 01), there are initiatives underway in the UK through the National Cancer Research Institute (NCRI) to increase the proportion of cancer patients aged 15–24 years who entered into trial protocols,[39] especially as the upper age range of paediatric trials are in the process of being extended. This may help to alleviate part of the survival disadvantage associated with older TYA given the lack of progress in survival rates observed in this analysis since 1990.

Trial entry, however, did not explain the significant survival gap between 15–24 and 0–14-year-olds. According to our data, entry into trial had only a modest beneficial effect on survival mainly restricted to leukaemia, especially AML. This is supported by other population-based analyses showing similar survival rates for those with ALL aged 15–29 years who did or did not enter into national clinical trials.[37] Although the difference in survival for the cohort treated on study compared to off-study might be expected to be small, the process of entry of populations into trials might underpin a significant amount of the improvement in survival for younger children over recent decades, an effect which is less apparent in TYA.

Improving trial entry and the delivery of care among 0–24-year-olds are currently being reviewed and implemented in the UK through the Improving Outcomes Guidance for children and young people.[40] The findings from this work from the Yorkshire and the Northern Regions, covering around 15% of the population in England, will therefore add substantially to the increasing level of information on incidence and survival trends for cancer in young people at a national level. It is encouraging that recommendations from the Improving Outcomes Guidance are beginning to be addressed in terms of setting up a national cancer intelligence function focusing on TYA cancers.

We did not find any evidence to support the hypothesis that incidence rates for leukaemia or lymphoma were higher in more affluent socio-economic areas for children or young adults (15–24), as previously noted for childhood ALL,[13] childhood lymphoma[14] and NHL in TYA.[36] This null observation was similar across the Yorkshire and the Northern Regions. Furthermore, no significant association was observed between deprivation and survival, similar to that reported by other UK studies in children and young people.[2,19]

Similar incidence and survival trends were observed across the Yorkshire and the Northern Regions. Further analysis of the observation that survival for AML was significantly higher in the Northern Region suggested that this may partly have arisen due to patient casemix. An excess of females aged 0–14 years in the Northern Region (60%) was notably higher than in Yorkshire (46%), whilst for 15–24s this effect was reversed so that only 40% of Northern Region subjects were female compared to 58% in Yorkshire. Variations in casemix within the Northern Region therefore accentuated survival differences by region since prognosis was better among females aged 0–14 years and males aged 15–24 years.

During the 1990s, specialist centres administering age-appropriate care for TYA began to address the needs of this unique population across England. This pioneering work has led to a point where the treatment and multidisciplinary care of TYA with cancer should no longer lag behind that of younger children[39] and be bespoke for this age group. The subsequent impact of care in these dedicated centres on survival, quality of life, secondary cancers and ultimately the reintegration into the society of young people with cancer should be examined in the context of these results.

Conflict of interest statement

None declared.

Financial interests

None.

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