Survival from childhood cancer in northern England, 1968–2005

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BACKGROUND: Cancer is the second most common cause of death in children in the developed world. The study investigated patterns and trends in survival from childhood cancer in patients from northern England diagnosed 1968–2005.

METHODS: Five-year survival was analysed using Kaplan–Meier estimation for four successive time periods. Cox regression analysis was used to explore associations with age and demographic factors.

RESULTS: The study included 2958 cases (1659 males and 1299 females). Five-year survival for all cancers improved significantly from 39% in 1968–1977 to 79% in 1998–2005 (P<0.001). Five-year survival for leukaemia increased from 24% to 81% (P<0.001), lymphoma from 46% to 87% (P<0.001), central nervous system tumours from 43% to 73% (P<0.001), bone tumours from 21% to 75% (P<0.001), soft tissue sarcoma from 30% to 58% (P<0.001) and germ cell tumours from 59% to 97% (P<0.001). Survival was worse for cases of acute lymphoblastic leukaemia (P<0.001) and astrocytoma (P<0.001) aged 10–14 years compared with 0–4-year olds.

CONCLUSION: There were marked improvements in survival over a 38-year time span. Future work should examine factors that could influence further improvement in survival such as diagnosis delays.

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Cancer is the second most common cause of death in children, aged 0–14 years, in the developed world. The continuous improvement in diagnostic and treatment strategies for cancer has led to significant improvements in survival for a wide range of childhood cancers (Kaatsch, 2010). Survival from childhood cancer in the United Kingdom has been included in international comparisons since the start of the European Cancer Registry-based Study on Survival and Care of Cancer Patients (EUROCARE) and the Automated Childhood Cancer Information System project (ACCIS) studies (Coebergh et al, 2001; Steliarova-Foucher et al, 2004; Pritchard-Jones et al, 2006; Gatta et al, 2009). Five-year survival for all European childhood cancers diagnosed during 1995–2002 was 81% (Gatta et al, 2009). Survival from childhood cancer in Great Britain (GB) improved substantially between 1971 and 1985 with 5-year survival reaching 76% for all cancer cases diagnosed during 1980–1991 (Stiller and Bunch, 1990; Stiller, 1994). A previous study from the Northern Region of England has examined survival in children and young adults diagnosed during the period 1968–1995 and reported significant improvements (Cotterill et al, 2000).

Population-based cancer registry data are regarded as highly reliable for comparison and analysis of survival (Pritchard-Jones and Stiller, 2007).

The aim of the present study was to investigate survival for cancer in children (aged 0–14 years) diagnosed during the period 1968–2005, and registered by the population-based Northern Region Young Persons’ Malignant Disease Registry (NRYPMDR). The study examined patterns and trends in survival, updating the previously published analysis and also presents separate diagnostic- and gender-specific results.

MATERIALS AND METHODS

All cases aged 0–14 years diagnosed with a primary malignancy during the period 1968–2005 were obtained from the NRYPMDR. The NRYPMDR is a specialist registry, established in 1968, covering the counties of Northumberland, Tyne and Wear, Durham, Teeside and Cumbria (excluding Barrow-in-Furness). All cases of cancer in the region, diagnosed in 0–24-year olds, are notified to the registry. Cases are identified from multiple sources. Consultants throughout the region notify the registry of any malignancies in this age group. Data are periodically crosschecked with regional cancer registries. The registry has a high level of overall completeness and ascertainment, estimated to be >98%, with a very small proportion of cases lost to follow-up (<1% over the entire study period). Follow-up was achieved by regular checking of death certificates and hospital admission data (Cotterill et al, 2000). Previously registry data were grouped according to a modified version of the International Classification of Diseases for Oncology (ICDO-2; Kramárová et al, 1996) and modifications are documented by Cotterill et al (2000). The International Classification of Childhood Cancer third edition (ICCC-3) for coding morphology and primary site of diagnosis is now followed (Steliarova-Foucher et al, 2005). Following the ICCC third edition, benign and uncertain behaviour neoplasms of intracranial and intraspinal sites are included in both the central
nervous system (CNS) tumour and the non-gonadal germ cell
tumours groups. Myelodysplastic syndrome and other myelopro-
filerative diseases are included under the subgroup ‘other
leukaemia’.

Statistical analysis
Survival at 5 years was analysed using Kaplan–Meier estimation,
for each diagnostic group, within four successive subperiods
1968–1977, 1978–1987, 1988–1997 and 1998–2005 (Kaplan
and Meier, 1958). Unadjusted trends in survival for each diagnostic
group were assessed using log rank tests. The end point of interest
was death from any cause, with date of diagnosis taken to be the
time of origin. The NRYPMDR attempts to obtain comprehensive
long-term follow-up on all childhood patients and was mostly
complete until 31 December 2008.

Cox Proportional hazards regression analysis was used to model
the probability of survival in relation to age at diagnosis (0–4, 5–9
and 10–14 years), gender, subperiods of diagnosis (1968–1977,
1978–1987, 1988–1997 and 1998–2005), area-level socioeconomic
depression quintiles and area-level population density for all
diagnostic groups and subgroups with >45 cases for the entire
follow-up period. The significance of each covariate in the model
was assessed using the partial likelihood ratio test. Non-nested
models were compared using Akaike’s Information Criterion
(Collett, 2003). Hazard ratios (HRs) of variables were retained in
the model only if they contributed significantly to the overall
model fit. Simpler models, fitting subperiod of diagnosis and
depression as continuous variables, were also assessed. The
proportional hazards assumption was tested by examining
Schoenfeld residuals and only those models that met the
assumption were included in the results (Cox, 1972).

Cases were divided into five groups on the basis of the quintile
of the distribution of Townsend deprivation score for the census
ward of residence, from the most affluent to the most deprived
(Townsend et al, 1988). Townsend scores were based on 1971,
1981, 1991 and 2001 censuses estimated for 2001 census ward
geography (Norman et al, 2008; Norman, 2010). Population
density for each electoral ward was calculated by dividing the
population by the area. Wards were classified according to tertile
of population density (for the period 1968–1985: low population
density 2–1103 persons per km², medium population density
1118–3290 persons per km², high population density 3300–11 357
persons per km²), for the period 1986–1995: low 2–1052 persons
per km², medium 1058–3094 persons per km², high 3113–10 680
persons per km²; for the period 1996–2005: low 2–978 persons
per km²; and for the period 1996–2005: low 2–978 persons
per km², medium 981–2933 persons per km², high 2974–
8882 persons per km²). The ward population density figures for the
periods 1968–1985, 1986–1995 and 1996–2005 were based,
respectively, on the 1981, 1991 and 2001 censuses estimated for
2001 census ward geography. Statistical significance was taken to
be P<0.05 in all analyses. Stata version 10 was used for the
statistical analysis.

RESULTS
The study included a total of 2958 childhood cancer cases,
diagnosed during the period 1968–2005 (1659 males and 1299
females). Five-year survival by period of diagnosis, for the
diagnostic groups and subgroups is given in Table 1 and for
males and females in Tables 2 and 3, respectively. Survival
increased significantly over the study period (P<0.001) from a 5-
year rate of 39% for the subperiod 1968–1977 to 60% for 1978–
1987, 75% for 1988–1997 and 79% for 1998–2005 (Figure 1A).
For all leukaemia and lymphoma combined survival increased from
29% to 60%, 78% and 83% for the four subperiods, respectively
(P<0.001). Similarly, survival for solid tumours increased from
45% to 59%, 72% and 77%, respectively (P<0.001). Cox modelling
showed there was little or no evidence of gender differences for
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Survival improved significantly over the study period for all
leukaemias and specifically for acute lymphoblastic leukemia (ALL; Figures 1B
and C). Five-year survival for ALL increased from 30% in the first
subperiod to 62%, 78% and 82% in the second, third and fourth
subperiods, respectively (P<0.001). Cox regression modelling for
ALL cases showed that age at diagnosis and categorical period of
diagnosis were significant in the final model (P<0.001). After
adjustment for period of diagnosis, the risk of death was higher for
10–14-year olds compared with those aged 0–9 years (HR = 1.76;
95% CI = 1.35–2.30). Survival for acute non-lymphocytic leukaemia
(ANLL) was very low in the earlier half of the study but
improved markedly during the latter half with a significantly large
increase from 14% in 1978–1987 to 78% in 1988–1997 and 77% in
1998–2005 (P<0.001).

Leukaemia
There was a significant increase in survival for all leukaemias and
specifically for acute lymphoblastic leukaemia (ALL; Figures 1B
and C). Five-year survival for ALL increased from 30% in the first
subperiod to 62%, 78% and 82% in the second, third and fourth
subperiods, respectively (P<0.001). Cox regression modelling for
ALL cases showed that age at diagnosis and categorical period of
diagnosis were significant in the final model (P<0.001). After
adjustment for period of diagnosis, the risk of death was higher for
10–14-year olds compared with those aged 0–9 years (HR = 1.76;
95% CI = 1.35–2.30). Survival for acute non-lymphocytic leukaemia
(ANLL) was very low in the earlier half of the study but
improved markedly during the latter half with a significantly large
increase from 14% in 1978–1987 to 78% in 1988–1997 and 77% in
1998–2005 (P<0.001).

Lymphoma
Survival improved significantly over the study period for all
lymphomas (P<0.001; Figure 1D). Survival for HL improved over
the study period (P=0.003) from a high level of 73% in the first
subperiod to 90% in the second subperiod but with little
subsequent improvement. Cox regression modelling for HL cases
showed that gender and subperiod of diagnosis as a continuous
variable were significant in the final model. After adjustment for
period of diagnosis, girls had a higher risk of death compared with
boys (HR = 3.43; 95% CI = 1.37; Figure 2). There was a marked
improvement in 5-year survival for non-Hodgkin lymphoma
(NHL) from 23% to 83% in the fourth subperiod (P<0.001), as
shown by the Cox analysis (P for linearity <0.001).

CNS tumours
Survival improved significantly over the study period for all cases
of CNS tumours combined, with 5-year survival improving from
43% to 73% (P<0.001; Figure 1E). There were significant
improvements in survival for ependymoma from 39% to 69%
(P=0.013) and for astrocytoma from 60% to 77% (P=0.049), but
the apparent improvement for primitive neuroectodermal tumours
(PNETs) from 24% to 63% was not significant (P=0.236).

Epidemiology

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Table 1  Percentage 5-year survival by time period and diagnostic group

| Diagnostic group | 1968–1977 | 1978–1987 | 1988–1997 | 1998–2005 | P for trend | P for linearity |
|------------------|-----------|-----------|-----------|-----------|------------|---------------|
| N                | % Survival | 95% CI    | % Survival | 95% CI    | % Survival | 95% CI        | % Survival | 95% CI        | P for trend | P for linearity |
| Leukaemia        | 895       | 24        | 19–30     | 56        | 49–62      | 77          | 72–82      | 81          | 73–87      | <0.001    | —            |
| ALL              | 742       | 30        | 24–36     | 62        | 55–68      | 78          | 71–83      | 82          | 73–88      | <0.001    | —            |
| ANLL             | 128       | 2         | 0–10      | 14        | 5–30       | 78          | 55–90      | 77          | 55–89      | <0.001    | —            |
| Lymphoma         | 289       | 46        | 34–57     | 74        | 62–83      | 80          | 69–88      | 87          | 76–94      | <0.001    | <0.001      |
| Hodgkin          | 128       | 73        | 54–85     | 90        | 73–97      | 96          | 77–99      | 93          | 73–98      | 0.003     | 0.003       |
| Non-Hodgkin      | 134       | 23        | 11–37     | 62        | 45–75      | 65          | 46–78      | 83          | 55–94      | <0.001    | <0.001      |
| Carcinomas       | 93        | 65        | 40–82     | 88        | 59–88      | 72          | 59–81      | 77          | 63–87      | 0.049     | 0.026       |
| CNS              | 702       | 43        | 35–50     | 60        | 52–66      | 64          | 56–71      | 73          | 64–80      | <0.001    | <0.001      |
| Ependymoma       | 72        | 39        | 17–60     | 26        | 11–45      | 75          | 41–91      | 69          | 34–88      | 0.013     | 0.02        |
| Astrocytoma      | 264       | 60        | 46–72     | 79        | 65–88      | 72          | 59–81      | 77          | 63–87      | 0.049     | 0.026       |
| PNET             | 124       | 24        | 11–41     | 45        | 27–61      | 43          | 23–62      | 63          | 39–80      | 0.236     | —           |
| Peripheral nervous system tumours |
| Neuroblastoma    | 197       | 17        | 7–29      | 32        | 20–45      | 52          | 38–63      | 66          | 45–80      | <0.001    | <0.001      |
| Retinoblastoma   | 187       | 13        | 5–25      | 33        | 20–46      | 51          | 37–63      | 65          | 45–80      | <0.001    | <0.001      |
| Retinoblastoma   | 88        | 92        | 76–97     | 86        | 54–96      | 96          | 75–99      | 100         | —          | 0.236     | —           |
| Renal tumours    | 159       | 63        | 48–75     | 76        | 58–87      | 83          | 69–91      | 90          | 66–98      | 0.029     | 0.004       |
| Wilms tumour     | 157       | 63        | 47–74     | 76        | 58–87      | 83          | 68–91      | 90          | 66–98      | 0.029     | 0.004       |
| Bone             | 126       | 21        | 10–34     | 34        | 19–51      | 71          | 51–85      | 75          | 50–89      | <0.001    | <0.001      |
| Osteosarcoma     | 74        | 17        | 6–33      | 50        | 26–70      | 71          | 43–87      | 69          | 30–89      | <0.001    | <0.001      |
| Ewing sarcoma    | 46        | 25        | 6–50      | 14        | 2–37       | 73          | 37–90      | 73          | 28–93      | 0.003     | 0.002       |
| Soft tissue sarcoma |
| Rhabdomyosarcoma | 202       | 30        | 19–42     | 53        | 38–66      | 69          | 55–80      | 58          | 36–75      | <0.001    | <0.001      |
| Germ cell tumour | 115       | 59        | 33–78     | 86        | 62–95      | 94          | 80–99      | 97          | 81–100     | <0.001    | <0.001      |
| Gonadoblastoma   | 50        | 70        | 33–89     | 88        | 59–97      | 100         | 100        | 100         | 100        | 0.023     | 0.023       |
| Non-gonadal      | 65        | 43        | 10–73     | 80        | 20–97      | 92          | 72–98      | 95          | 72–99      | 0.007     | 0.004       |
| Carcinomas       | 93        | 65        | 40–82     | 88        | 59–97      | 89          | 72–96      | 76          | 47–90      | 0.273     | —           |
| Total leukaemia and lymphoma | 1184     | 29        | 24–34     | 60        | 55–66      | 78          | 73–82      | 83          | 77–88      | <0.001    | —           |
| Total solid tumours | 1774  | 45        | 41–50     | 59        | 54–64      | 72          | 68–76      | 77          | 72–81      | <0.001    | —           |
| Total all cancers | 2958     | 39        | 35–42     | 60        | 56–63      | 75          | 71–77      | 79          | 75–83      | <0.001    | —           |

Abbreviations: CI = confidence intervals; ALL = acute lymphoblastic leukaemia; ANLL = acute non-lymphocytic leukaemia; CNS = central nervous system; PNET = primitive neuroectodermal tumour. Table shows all diagnostic groups with >45 patients diagnosed over the study period. *Total including other miscellaneous groups.

ependymoma cases was better as deprivation got worse with HR decreasing by a factor of 0.77 (95% CI = 0.62–0.97) for each quintile of deprivation.

For astrocytoma cases, the final model included age at diagnosis, subperiod of diagnosis as a continuous variable and quintile of deprivation as a categorical variable. Survival for astrocytoma cases was better in the areas with the highest deprivation (HR = 0.36; 95% CI = 0.16–0.80). However, survival was significantly poorer for children aged 10–14 years (HR = 2.51; 95% CI = 1.37–4.62).

Peripheral nervous system tumours

There was a significant increase in overall survival for neuroblastoma from 13% to 65% (P < 0.001).

Retinoblastoma

Survival was consistently high and between 86 and 100% with no significant variation (P = 0.236).

Renal tumours

There was a significant increase in the overall survival for Wilms tumour (P = 0.029).

Bone tumours

Overall survival for bone tumours significantly increased from 21% to 75% (P < 0.001). Cox regression showed that the improvement in survival for both osteosarcoma and Ewing Sarcoma was steady (P < 0.001) and the apparent drop from 71% in the third period to 69% in the fourth period was most likely due to random sampling variation due to small numbers.

Soft tissue sarcomas

Survival significantly increased for all soft tissue sarcoma from 30% to 58% (P = 0.001) and specifically for rhabdomyosarcoma from 19% to 59% (P = 0.003). Cox regression showed that the improvement in survival for rhabdomyosarcoma was steady (P = 0.001) and the apparent drop from 62% in the third period to 59% in the fourth period was most likely due to random sampling variation.

Germ cell tumours

Five-year survival for all gonadal germ cell tumours significantly improved from 70% to 100% (P = 0.023). For all non-gonadal germ cell tumours, there was a significant increase in 5-year survival from 43% to 95% (P = 0.007).
### Table 2  Percentage 5-year survival by time period and diagnostic group for males

| Diagnostic group | 1968–1977 | 1978–1987 | 1988–1997 | 1998–2005 | P for trend |
|------------------|-----------|-----------|-----------|-----------|------------|
|                  | N         | % Survival | 95% CI | % Survival | 95% CI | % Survival | 95% CI | % Survival | 95% CI | p         |
| Leukaemia        | 509       | 24        | 17–31  | 53        | 44–61  | 74        | 66–81  | 81        | 70–89  | <0.001    |
| ALL              | 428       | 28        | 21–37  | 59        | 49–68  | 74        | 65–81  | 82        | 69–90  | <0.001    |
| ANLL             | 70        | 4         | 0–17   | 21        | 7–41   | 85        | 51–96  | 72        | 34–90  | <0.001    |

**Lymphoma**

| Hodgkin         | 215       | 53        | 39–65  | 70        | 56–80  | 86        | 73–93  | 92        | 76–97  | <0.001    |
| Non-Hodgkin     | 103       | 82        | 62–92  | 88        | 67–96  | 100       | 82–97  | 94        | 67–79  | 0.095     |

**CNS**

| Ependymoma      | 386       | 41        | 31–51  | 58        | 48–66  | 63        | 52–72  | 74        | 61–83  | <0.001    |
| Astrocytoma     | 137       | 57        | 37–73  | 81        | 62–91  | 68        | 49–81  | 74        | 49–88  | 0.158     |
| PNET             | 78        | 26        | 10–47  | 35        | 16–55  | 40        | 16–63  | 58        | 31–78  | 0.574     |

**Sympathetic nervous system**

| Neuroblastoma    | 102       | 13        | 3–30   | 25        | 11–42  | 47        | 28–63  | 53        | 26–75  | 0.002     |

**Renal**

| Wilms tumour     | 70        | 57        | 34–74  | 82        | 45–95  | 85        | 64–94  | 72        | 24–93  | 0.140     |

**Bone**

| Soft tissue sarcoma | 217       | 29        | 13–48  | 23        | 6–47   | 60        | 32–80  | 92        | 57–99  | <0.001    |

**CNS**

| Ependymoma       | 316       | 44        | 33–54  | 58        | 51–65  | 77        | 71–83  | 85        | 76–90  | <0.001    |
| Astrocytoma      | 127       | 24        | 7–45   | 52        | 31–70  | 63        | 35–81  | 58        | 28–79  | 0.071     |
| PNET             | 46        | 20        | 3–47   | 64        | 30–85  | 50        | 15–77  | 78        | 36–94  | 0.413     |

**Sympathetic nervous system**

| Neuroblastoma    | 95        | 21        | 7–41   | 41        | 21–60  | 57        | 37–72  | 76        | 45–91  | <0.001    |

**Retinoblastoma**

| Wilms tumour     | 88        | 69        | 48–83  | 74        | 51–87  | 81        | 57–92  | 100       | 49–93  | <0.001    |

**Bone**

| Soft tissue Sarcoma | 59        | 11        | 2–28   | 42        | 20–62  | 85        | 51–96  | 47        | 12–76  | 0.001     |

**Germ cell tumour**

| Carcinomas       | 54        | 69        | 37–87  | 91        | 51–99  | 86        | 62–95  | 76        | 33–94  | 0.500     |

**Total leukaemia and lymphoma**

| Total solid tumours | 1659      | 103       | 3–30   | 25        | 11–42  | 47        | 28–63  | 53        | 26–75  | 0.002     |

| Total all cancers  | 1235      | 102       | 3–30   | 25        | 11–42  | 47        | 28–63  | 53        | 26–75  | 0.002     |

**Abbreviations:** CI = confidence intervals; ALL = acute lymphoblastic leukaemia; ANLL = acute non-lymphocytic leukaemia; CNS = central nervous system; PNET = primitive neuroectodermal tumour. Table shows all diagnostic groups with >45 patients diagnosed over the study period.

### Table 3  Percentage 5-year survival by time period and diagnostic group for females

| Diagnostic group | 1968–1977 | 1978–1987 | 1988–1997 | 1998–2005 | P for trend |
|------------------|-----------|-----------|-----------|-----------|------------|
|                  | N         | % Survival | 95% CI | % Survival | 95% CI | % Survival | 95% CI | % Survival | 95% CI | p         |
| Leukaemia        | 386       | 25        | 17–32  | 60        | 50–69  | 82        | 73–89  | 81        | 68–89  | <0.001    |
| ALL              | 314       | 31        | 22–41  | 65        | 54–74  | 84        | 73–90  | 82        | 65–91  | <0.001    |
| ANLL             | 58        | 0         | —      | 0         | —      | 70        | 33–89  | 80        | 49–93  | <0.001    |

**Lymphoma**

| Hodgkin         | 74        | 20        | 5–42   | 92        | 57–99  | 65        | 40–82  | 79        | 57–91  | <0.001    |
| Non-Hodgkin     | 316       | 44        | 33–54  | 63        | 50–73  | 65        | 53–75  | 73        | 59–82  | <0.001    |
| CNS              | 127       | 64        | 42–79  | 76        | 52–89  | 77        | 57–88  | 80        | 63–90  | 0.300     |
| Ependymoma       | 46        | 20        | 3–47   | 64        | 30–85  | 50        | 15–77  | 78        | 36–94  | 0.413     |

**Sympathetic nervous system**

| Neuroblastoma    | 95        | 21        | 7–41   | 41        | 21–60  | 57        | 37–72  | 76        | 45–91  | <0.001    |

**Retinoblastoma**

| Wilms tumour     | 88        | 69        | 48–83  | 74        | 51–87  | 81        | 57–92  | 100       | 49–93  | <0.001    |

**Bone**

| Soft tissue Sarcoma | 59        | 11        | 2–28   | 42        | 20–62  | 85        | 51–96  | 47        | 12–76  | 0.001     |

**Germ cell tumour**

| Carcinomas       | 54        | 69        | 37–87  | 91        | 51–99  | 86        | 62–95  | 76        | 33–94  | 0.500     |

**Total leukaemia and lymphoma**

| Total solid tumours | 1659      | 102       | 3–30   | 25        | 11–42  | 47        | 28–63  | 53        | 26–75  | 0.002     |

| Total all cancers  | 1235      | 102       | 3–30   | 25        | 11–42  | 47        | 28–63  | 53        | 26–75  | 0.002     |

**Abbreviations:** CI = confidence intervals; ALL = acute lymphoblastic leukaemia; ANLL = acute non-lymphocytic leukaemia; CNS = central nervous system; PNET = primitive neuroectodermal tumour. Table shows all diagnostic groups with >45 patients diagnosed over the study period.
Carcinomas

The apparent increase in survival for carcinomas was not statistically significant ($P = 0.273$).

DISCUSSION

This study provides up-to-date estimates of childhood cancer survival from a population-based cancer registry in northern England. The population of the Northern Region is ethnically homogenous with fewer than 2% from ethnic minorities (Office of Population Censuses and Surveys Census Division, General Register Office (Scotland) Census Branch, 1983; Office for National Statistics, 1991, 2001). The incidence of childhood cancer in this area is similar to England in general (Magnanti et al, 2008a, b). Five-year survival for all cancer in children (aged 0–14 years) has improved considerably over the study period. The largest improvements in survival in more recent years were seen for ANLL (from the third subperiod) and for NHL and sympathetic nervous system tumours (especially in the last subperiod). However, the new data showed continued improvements in survival for the groups comprising all cancers, all haematological malignancies and all solid tumours since the previously published report (Cotterill et al, 2000). The previously published study only reported survival for all cancers, haematological malignancies and solid tumours collectively; in the present study, we report both diagnostic- and gender-specific survival.

The improvement in overall cancer survival during the study period is consistent with other studies. The overall 5-year survival from cancer was similar to a previous report from the whole of the United Kingdom where the 5-year survival for the period 1991–2000 was 75% (Stiller, 2007). Our findings were also similar to those reported by other studies, including the EUROCARE study (5-year survival for all childhood cancers combined, diagnosed 1995–2002: 81%; Gatta et al, 2009), the Surveillance, Epidemiology and End Results (SEERs) programme in the United States (cases diagnosed 1999–2006: 79.9%; Altekruse et al, 2010) and from Australia (cases diagnosed 1997–2006: 79.5%; Baade et al, 2010).

For specific diagnostic subgroups, similar findings were also reported. Childhood cancer survival figures reported from the SEER and the Australian studies were produced using relative survival. However, the results from the EUROCARE study were observed survival. Using relative survival makes little difference to the estimates because deaths due to other causes are rare in children (Gatta et al, 2009).

In GB, the 5-year survival for ALL, HL and NHL diagnosed during 1991–2000 was 87%, 95% and 79%, respectively (Stiller, 2007); and for all European children, diagnosed in 1995–2002 were 85%, 95% and 82% (Gatta et al, 2009). Since the greatest improvements in survival for leukaemia in early 1990s there have been very little subsequent improvements.
The 5-year survival for ALL has seen great improvements for children diagnosed 1987–2005 (77%) and the reason for this improvement was likely to be due to additional more intensive therapy protocols that were introduced by the United Kingdom Medical Research Council (UK MRC) trials in early 1980s (Gibson et al, 2005). These protocols have been followed in the treatment centres in the northern region. The 5-year overall survival for children with ALL who were treated on UK MRC trials between 1988 and 2002 was 66% (Gibson et al, 2005) and for ALL cases diagnosed 1996–2000 in GB was 65% (Stiller, 2007).

The overall 5-year survival results for CNS tumours showed significant improvements and there were non-significant improvements for PNETs. CNS tumours are a very heterogeneous diagnostic group. Five-year survival from the United Kingdom, for cases diagnosed during 1991–2000 was 69%, 66% and 79% for all CNS tumours, ependymoma and astrocytoma, respectively (Stiller, 2007). Five-year survival for astrocytoma diagnosed 1995–2005 reported for Europe (78%) (Gatta et al, 2009) was similar to the present study (77%), but the 5-year survival for astrocytoma diagnosed during 1999–2006 reported in the United States by the SEER programme (Altekruse et al, 2010) was higher (84.8%), although the same ICCC-3 classification of coding morphology was followed by the three studies (Steliarova-Foucher et al, 2005). Survival for PNETs reported in the current study (63%) is similar to that reported from the EUROCare study for embryonal CNS tumours (which were mainly medulloblastoma and PNET) diagnosed during 1995–2002 (66%) (Gatta et al, 2009).

For peripheral nervous system tumours, which comprise mainly neuroblastoma, we found recent marked increases in the 5-year survival especially in the last subperiod. An increase in survival for neuroblastoma cases diagnosed in the United Kingdom was persistent over the time period, with the greatest increases in survival from 1971–1975 to 1981–1985 with little change in 1986–1990 but then followed by a further increase in 1996–2000 (Stiller, 2007). Our results show that the 5-year survival for neuroblastoma in the last subperiod was 65%, which is higher than the 5-year survival reported from the whole of United Kingdom, for cases diagnosed 1991–2000 (59%) (Stiller, 2007), but lower than reported from Europe (72%) (Gatta et al, 2009) and the United States (73%) (Altekruse et al, 2010).

The overall 5-year survival for bone tumours diagnosed during 1998–2005 (75%; osteosarcomas: 69%; Ewing tumours: 73%) was higher than that reported from the earlier study from Northern England and the West Midlands for cases diagnosed 1981–2000 where overall 5-year survival for the period 1995–2000 was 62% (osteosarcomas: 57% and Ewing sarcoma: 70%; Eyre et al, 2009).

Soft tissue sarcoma had the lowest 5-year survival of all diagnostic groups (58%) which is lower than rates reported from the United Kingdom for cases diagnosed 1991–2000 (66%; Stiller, 2007). Germ cell tumours had the highest 5-year survival and this was similar to previous reports from the United Kingdom (Stiller, 2007) and from Europe (Gatta et al, 2009).

The Cox regression analyses showed that survival for ALL and astrocytoma was influenced by age of the patients, with older children faring worse. Our data are consistent with findings from the whole of the United Kingdom for ALL and astrocytoma where older children aged 5–14 years had worse prognosis than children aged 1–4 years (Stiller, 2007). The age at which children are diagnosed with cancer is an important prognostic factor for several childhood cancers, which may be used in several classifications of high risk patients and stratification for treatment (Coebergh et al, 2001). Children diagnosed with ALL, who were patients in the UK MRC clinical trials protocols between 1980 and 2001, and who were older than 10 years were consistently associated with high risk disease and worse outcome compared with children younger than 10 years (Mitchell et al, 2010). Also, the delay in access to care among adolescents diagnosed with cancer may contribute to worse survival for older children (Albritton and Eden, 2008). Survival from ALL is reported to be worse in adolescent groups compared with younger patients (Feltbower et al, 2009).

There were no significant differences in survival for any of the cancer types by area-level socioeconomic deprivation except for CNS tumours where survival was better for children resident in more deprived areas compared with those from more affluent areas. A similar unexpected association between poorer survival and higher affluence was previously reported for children and young adults diagnosed with CNS tumours in Yorkshire (Feltbower et al, 2004). These findings were in contrast to the data from England and Wales. Coleman et al (1999) have shown that deprivation has a strong influence on cancer survival rates in adults, but much less influence in children. The findings of the present study may reflect the fact that more deprived areas are more likely to be associated with lower affluence.

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