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Is mortality after childhood cancer dependent on social or economic resources of parents? A population-based study

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Diagnostic and treatment protocols for childhood cancer are generally standardized, and therefore, survival ought to be fairly equal across social strata in societies with free public health care readily available. Nevertheless, our study explores whether there are disparities in mortality after childhood cancer in Norway depending on socioeconomic status of parents. Limited knowledge on differentials exists from earlier analyses. Discrete-time hazard regression models for all-cause mortality for the first 10 years after diagnosis were estimated for all Norwegian children (younger than 20 years), who were diagnosed with cancer during 1974–2007 (N = 6,280), using data from five national registers. Mortality was reduced by about 15% for children with highly educated mothers and children without siblings. These effects were most pronounced for cancers predicted to encompass intense, long-lasting treatments resulting in chronic health problems. Neither earnings nor the marital status of parents affected children's survival. This large, registry-based study suggests that time constraints and various noneconomic rewards of parents from their education appears to have an impact on childhood cancer survival. It may be that children with resourceful parents are healthier at the outset and/or are more likely to avoid later health problems. It may also be that children of well-informed and strongly involved parents are offered better treatment or are able to make better use of what is offered, for instance, by adhering more closely to recommendations for follow-up treatment. The possibility of such differentials in offered and actual treatment should be addressed in future research.

The general inverse association between childhood mortality and socioeconomic status is well established.[1] However, little is known about the impact of specific parental socioeconomic resources on childhood cancer survival.[2–9] Diagnostic procedures and treatment protocols for these diseases are largely standardized and centralized in developed countries,[10] and childhood cancer survival is therefore assumed to be fairly equal across different social groups.

For children with cancer and their families, it is important to ensure that treatment outcomes are maximized. If survival differences exist across social groups, clinical interventions ought to be targeted to ensure optimal care for all. Therefore, we explore the extent to which mortality after childhood cancer depends on parental resources or socioeconomic status more generally in a society with presumably equal access to high quality cancer care.

The Norwegian public health care system offers all residents free cancer diagnosis and treatment.[11] Private health services that exist typically handle less critical conditions and provide neither primary nor follow-up treatment for cancer. Further, because of highly standardized procedures conducted within centralized designated pediatric hospital departments,[11,12] children supposedly receive the same initial and subsequent treatment regardless of where in the country they live and independent of resources and personal initiatives of their parents *vis-à-vis* health personnel. Thus, if there were no other determinants of the survival from these cancers, one would expect to see small differentials in survival by, for example, education or other sociodemographic characteristics of parents. However, reality may be more complex. Treatments may perhaps be less standardized than widely assumed, and there may be sociodemographic variations in the abilities of families to comply with the recommendations for follow-up assessments and treatment, in developed countries as well as in poorer settings.[7,13] This might be of particular relevance in out-patient hospital settings or community-based primary care settings, where patients in general have to take on more responsibility to achieve appropriate care. Cancer may also be diagnosed earlier in some social groups than others, which may be important for survival. In addition, some children may have poorer health than others at the time of diagnosis, with consequences for survival prospects, or they may develop diseases after diagnosis that are unrelated to the malignancy but increase the chance of dying from it. These so-called "host factors" are probably influenced by, for example, socioeconomic resources of families, as is all-cause mortality in this age group.[1]

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Our study aims to assess whether mortality from childhood cancer in Norway is influenced by the mother's age, education and marital status, the combined annual labor earnings of mother and father and whether they have additional children. If effects of this kind are observed after taking stage at time of diagnosis into account, one or more of the other aforementioned mechanisms must have some relevance. Should there be no effect, the pathways either counteract each other or they are all unimportant, which may suggest that the public health care system serves one of its major purposes well.

Discrete-time hazard regression models are estimated from nationwide registers, and all-cause mortality among all Norwegian children younger than 20 years, who are diagnosed with cancer between 1974 and 2007, is assessed. No earlier Norwegian study has addressed the possibility of sociodemographic variations in childhood cancer survival, but such variations in adult cancer survival have been documented.[14–16] There is also limited knowledge about the importance of socioeconomic resources of parents from other countries, where effects also may be expected to be dissimilar because of inherent differences in the health care and welfare systems. One study from New Zealand showed that cancer survival was significantly reduced if a parent did not have a registered occupation or if a parent was unemployed, and an adverse effect of low education was also weakly indicated, while single parenthood had no impact.[2] Similarly, ethnicity did not play a role.[4] A relatively small, older study from the Netherlands concluded that educational level of parents had only a minor impact on childhood leukemia survival in the period 1973–1979.[5] A Korean study from 2009 found that parental resources played a minor role,[3] whereas a more recent study by the same authors found a clear inverse relationship between childhood cancer mortality and parental socioeconomic position.[9] In developing countries, parental resources have been documented to have a significant beneficial effect.[7,8]

Survival rates have improved substantially over the last decades for most childhood cancers.[17] However, childhood cancers represent diverse diseases treated differently and with dissimilar risks for poor outcomes.[17–20] Thus, the burden associated with modern pediatric oncology treatment varies considerably, as certain cancers are treated by one modality for a short period of time, whereas others involve active multimodal treatments for many years often associated with potential life-threatening complications.[21] The latter treatments also require prolonged and more frequent hospitalizations in which one of the parents generally accompanies the child. In our study, we assess whether the sociodemographic variation in survival is more pronounced in the latter cases, which seems highly likely.

Material and Methods

Data on all Norwegian children diagnosed with cancer at age 0–19 years from 1974 to 2007 ($N = 6{,}280$) and on their parents were extracted from five sources and linked by means of the personal identification number assigned to everyone who has lived in Norway after 1960 (Tables 1 and 2). The "Norwegian Population Register," the "Norwegian Education Register" and the "Norwegian Directorate of Taxes" provided information on the children's date of birth, death or emigration, identifiers of the parents, dates of birth of the parents and their other children, dates of death or emigration of parents, their highest attained education, their marital status and their gross labor earnings. Information on cancer form, stage and date of diagnosis was extracted from the "Cancer Registry of Norway," which has registered all cancer diagnoses nationwide since 1953. Mandatory reporting from clinicians, pathologists and death certificates ensures completeness and high data quality.[22] Data on initial and subsequent courses of treatment are unfortunately not available. The "Cause-of-Death Registry" provided information on cause of death for the children who died. Children whose parents could not be identified (1%) were excluded from the analysis.

For each child, a series of 1 month observations were created, starting at time of diagnosis and ending at time of death or emigration, when a second cancer was diagnosed, after 10 years had passed since diagnosis, or on December 31, 2007, whichever occurred first. Each observation included various characteristics of the child, its disease and its parents. The outcome variable was whether the child died within the month or not. The statistical significance level was set at 5%. Almost all deaths (*i.e.*, >95%) were registered as due to cancer. Counting only these (*i.e.*, analyzing so-called "corrected survival" rather than "observed survival") gave very similar results. Logistic models were estimated from the entire pool of 1 month observations, using the Proc Logistic procedure in SAS® 9.2.[23] In total, there were 1,619 deaths within 500,837 person-months of observation. On average, each child contributed 6.7 observation years.

All models included time since diagnosis, child's age at diagnosis, current calendar year, whether the parents were married to each other at time of diagnosis, number of siblings, mother's age when the child was born, her education at time of diagnosis and the average combined earnings of the mother and the father during the last 3 years before diagnosis (Table 3). There were few observations with missing values on one or more of the variables included in the final model, and the point estimates remained virtually unchanged after their exclusion (not shown). The largest number of missing values was seen for education and marital status (2.8 and 2.6%, respectively), whereas the percentages missing for income, mother's age at birth and number of siblings were only 1.3, 0.7 and 0.7%, respectively. Number of siblings was defined as the number of other children born to the mother before the diagnosis, but the number of siblings on the father's side was nearly identical. Educational level of father could not be included in addition to that of the mother, because of a high degree of educational homogamy in Norway.[24] Substituting education of mothers with that of fathers yielded fairly similar estimates (not shown). For the same reason, only age of mothers was included.

Table 1. Characteristics of children with cancer at time of diagnosis and deaths per person–month[1]

Categories	*N*[2]	Percentage[3]	Deaths per person-months[4]
Cancer form			
Central nervous system tumor	1,524	24.3	434/115,541
Leukemia (ALL, AML and nos[5])	1,520	24.2	474/115,675
Acute lymphoblastic leukemia	940	15.0	281/85,342
Acute myelogenous leukemia	210	3.3	124/12,118
Leukemias, nos	370	5.9	69/18,215
Lymphoma	742	11.8	130/62,166
Germ cell cancer	509	8.1	61/47,449
Neuroblastoma	360	5.7	104/27,822
Bone cancer	352	5.6	151/23,928
Soft tissue cancer	256	4.1	74/20,094
Malignant melanoma	246	3.9	28/25,232
Renal cancer[6]	219	3.5	28/20,616
Endocrine cancer[7]	118	1.9	2/12,198
Hepatic cancer	86	1.4	33/5,544
Other or unknown	348	5.5	100/28,018
Cancer stage at diagnosis			
Local cancer	2,822	44.9	630/243,078
Regional cancer	670	10.7	202/48,911
Metastatic cancer	350	5.6	124/22,827
Unknown[8]	2,438	38.8	663/189,467
Age at diagnosis			
Child aged 0–4 years	1,791	28.5	448/145,376
Child aged 5–9 years	1,165	18.6	321/92,103
Child aged 10–14 years	1,088	17.3	307/85,511
Child older than or equal to 15 years	2,236	35.6	543/181,293
Year of diagnosis			
1974–1979	935	14.9	429/69,555
1980–1989	1,797	28.6	551/161,302
1990–1999	1,905	30.3	414/186,981
2000–2007	1,643	26.2	225/86,445

[1]Only the time invariant characteristics are shown here. [2]Number of children in the respective categories. [3]Percentage of children in the respective categories. [4]Number of child deaths per person-month. [5]Not otherwise specified. [6]Primarily Wilm's tumor. [7]Primarily thyroid cancer. [8]Including CNS tumors and around 60% of the lymphomas for which no stage is recorded. Abbreviations: ALL, acute lymphoblastic leukemia; AML, acute myelogenous leukemia; nos, not otherwise specified.

Some cancer types are more aggressive than others. In case these also occur more frequently in some groups than others, cancer type was controlled for in all models. However, it turned out that this adjustment was unnecessary, that is, the distribution of the cancer cases is fairly random. Stage at diagnosis was included in one model to assess its importance as a causally intermediate factor (Table 3). In a final step, models were estimated separately for mothers with a higher *versus* a lower education, for children with and without siblings at diagnosis, for cancer forms anticipated to create long-lasting care burdens *versus* the remaining and for an early (before 1990) *versus* later (during or after 1990) diagnostic period (Table 4). The cancer forms anticipated to involve long-term care burdens include central nervous system (CNS) tumors, leukemias (acute myelogenous leukemia excluded), neuroblastomas, and bone cancers.[21] These cut off points were chosen *a priori* based on knowledge of prognosis and treatment protocols for childhood cancer in Norway and the changes that have taken place over time.

Results

Descriptive statistics

The most common cancer forms among children were CNS tumors, leukemias, lymphomas, germ cell cancers and

Table 2. Characteristics of families of children at time of diagnosis and deaths per person-month[1]

Categories	N[2]	Percentage[3]	Deaths per person-months[4]
Age of mothers at child birth[5]			
Younger than 20 years[6]	830	13.2	226/69,280
20–24 years old	2,757	43.9	775/221,698
25–29 years old	1,965	31.3	467/157,315
30–34 years old	579	9.2	118/44,792
Older than 34 years	149	2.4	33/11,198
Education of mothers			
High school or below[6]	4,614	73.5	1,317/376,515
Any college education or above	1,666	26.5	302/127,768
Marital status of parents			
Married	4,296	68.4	1,120/352,229
Not married[6]	1,984	31.6	499/152,054
Number of siblings			
0[6]	991	15.8	222/81,367
1	2,514	40.0	647/203,095
≥2	2,775	44.2	750/219,821
Combined earnings of parents[7]			
<$10,000[6]	992	15.8	381/75,510
$10,000–$19,999	837	13.3	304/69,029
$20,000–$39,999	1,415	22.5	380/127,093
$40,000–$59,999	1,054	16.8	236/93,447
$60,000–$79,999	821	13.1	151/67,797
$80,000–$99,999	520	8.3	79/35,778
≥$100,000	641	10.2	88/35,629

[1]Only the time invariant characteristics are shown here. [2]Number of children with parents in the respective categories. [3]Percentage of children with parents in the respective categories. [4]Number of child deaths per person-month. [5]Age at birth of child later diagnosed with cancer. [6]Including also those with missing values. [7]Three-year average of combined gross annual labor earnings of parents before diagnosis. Excluding parents with missing earnings gave a median combined earnings at diagnosis of $47,000.

neuroblastomas (Table 1). Approximately 45% of the cancers were diagnosed at a localized stage, and only 6% had metastases at time of diagnosis. Cancer was most common among children older than 15 years (36%) and younger than 5 years (29%). The number of annual childhood cancer cases has been quite stable.[22]

The vast majority (75%) of the children had mothers who were between 20 and 29 years old at the time of their birth, and 27% had mothers with a tertiary education (Table 2). Approximately 16% did not have siblings at time of diagnosis, whereas 40% had one sibling, 28% had two siblings and 16% had three or more siblings. Nearly 70% of the children had parents who were married at time of diagnosis. Only approximately 5% of the births in Norway are to mothers who are neither cohabiting nor married,[25] so the remaining 30% of the children probably have either cohabiting parents or have experienced disruption and live with only one of the parents. The median annual combined gross labor market earnings of parents before diagnosis was $47,000, and only one-fourth of the children had parents who made <$10,000 or >$100,000 per year.

Mortality differentials after childhood cancer

Mortality increases from the first to the second half of the year after diagnosis and then declines (Table 3). As expected, the estimates also showed that there has been a substantial improvement in survival over time. The lowest mortality was seen for children diagnosed before the age of 15 years (a 22% advantage compared to the oldest children), those with no siblings (a 20% advantage) and those having mothers with a tertiary education (a 14% advantage). The survival was not affected by the marital status of parents, the mother's age at birth or the earnings of the parents. Mortality was highest for leukemia, bone cancer, hepatic cancer, soft-tissue cancer, neuroblastoma and CNS tumors. As expected, the outcome after localized cancer was clearly superior to that of more advanced cancer. When stage was included in the model, the effects of number of siblings and mother's education remained virtually unchanged (Table 3).

Table 3. Fully fitted models with and without stage at time of diagnosis and other variables possibly affecting children's probability of death[1]

	Model with stage		Model without stage	
	OR[2]	95% CI[3]	OR	95% CI
Educational level of mothers[4]				
High school or less[5]	1.00	ref	1.00	ref
College and above	0.86	0.75–0.99	0.83	0.72–0.96
Age of mothers at child birth				
<20 years old	0.97	0.82–1.15	0.98	0.83–1.17
20–24 years old	1.06	0.94–1.19	1.07	0.94–1.20
25–29 years old	1.00	ref	1.00	ref
30–34 years old	0.96	0.78–1.17	0.96	0.78–1.18
>34 years old	1.07	0.74–1.54	1.04	0.72–1.49
Marital status of parents[4]				
Married	1.02	0.90–1.15	1.01	0.90–1.14
Not married[5]	1.00	ref	1.00	ref
Combined earnings of parents[6]				
<$10,000[5]	1.09	0.88–1.34	1.09	0.88–1.35
$10,000–$19,999	1.00	0.81–1.23	1.00	0.81–1.23
$20,000–$39,999	0.93	0.78–1.12	0.95	0.79–1.13
$40,000–$59,999	1.00	ref	1.00	ref
$60,000–$79,999	0.96	0.78–1.19	0.97	0.78–1.20
$80,000–$99,999	0.90	0.69–1.18	0.91	0.69–1.19
≥$100 000	0.94	0.72–1.23	0.96	0.73–1.26
Number of siblings[4]				
0	0.80	0.68–0.94	0.82	0.69–0.97
1	1.00	ref	1.00	ref
≥2	0.95	0.85–1.06	0.96	0.86–1.07
Current calendar period				
1974–1979	2.55	2.03–3.19	2.33	1.86–2.91
1980–1984	1.74	1.42–2.13	1.66	1.36–2.03
1985–1989	1.31	1.09–1.58	1.28	1.06–1.54
1990–1994	1.00	ref	1.00	ref
1995–1999	0.84	0.69–1.03	0.89	0.73–1.08
2000–2007	0.60	0.50–0.74	0.68	0.56–0.83
Months since diagnosis				
1–6	1.24	1.04–1.49	1.30	1.08–1.56
7–12	1.42	1.18–1.70	1.46	1.22–1.75
13–18	1.19	0.98–1.44	1.20	0.99–1.46
19–24	1.00	ref	1.00	ref
25–36	0.55	0.45–0.68	0.55	0.45–0.67
37–48	0.38	0.30–0.48	0.37	0.29–0.47
49–60	0.30	0.23–0.39	0.29	0.22–0.38
61–120	0.13	0.10–0.16	0.12	0.09–0.15
Age at diagnosis				
Child aged 0–4 years	1.00	ref	1.00	ref

Table 3. Fully fitted models with and without stage at time of diagnosis and other variables possibly affecting children's probability of death[1] (Continued)

	Model with stage		Model without stage	
	OR[2]	95% CI[3]	OR	95% CI
Child aged 5–9 years	1.07	0.91–1.24	1.08	0.93–1.26
Child aged 10–14 years	1.11	0.95–1.31	1.11	0.95–1.31
Child $\geq$ 15 years	1.22	1.04–1.42	1.23	1.06–1.44
Cancer form				
Central nervous system tumor	1.98	1.27–3.08	2.66	1.79–3.94
Acute lymphoblastic leukemia	5.04	3.31–7.69	2.40	1.61–3.57
Acute myelogenous leukemia	13.48	8.64–21.01	6.37	4.18–9.71
Leukemia, nos[7]	6.60	4.09–10.64	2.84	1.80–4.48
Lymphoma	1.00	0.64–1.57	1.48	0.97–2.27
Germ cell cancer	0.82	0.51–1.32	0.91	0.57–1.45
Neuroblastoma	2.49	1.62–3.83	2.93	1.91–4.49
Bone cancer	3.49	2.29–5.33	3.66	2.40–5.58
Soft tissue cancer	3.16	2.01–4.96	2.49	1.59–3.90
Malignant melanoma	1.34	0.77–2.33	0.73	0.42–1.25
Renal cancer[8]	1.00	ref	1.00	ref
Endocrine cancer[9]	0.10	0.03–0.45	0.11	0.03–0.49
Hepatic cancer	3.24	1.86–5.65	4.37	2.61–7.34
Other or unknown	2.17	1.37–3.43	2.48	1.60–3.84
Stage at diagnosis				
Local cancer[10]	1.00	ref	N/A	N/A
Regional cancer	3.59	2.88–4.49	N/A	N/A
Metastatic cancer	6.59	5.09–8.53	N/A	N/A
Stage unknown or nos[11]	2.87	2.21–3.72	N/A	N/A

[1]Originally, all parental variables hypothesized to be of significance were included, and no considerations of colinearity were undertaken. Age and educational level of fathers were later excluded due to colinearity. Stage at diagnosis is a possible intermediate factor, but did not alter the effects of socioeconomic status of parents and was thus later excluded. [2]Odds Ratio. [3]Confidence interval. [4]At time of diagnosis. [5]Including also those with missing values. [6]The average of combined gross labor earnings of parents during the last 3 years before diagnosis. [7]Not otherwise specified (nos). [8]Primarily Wilm's tumor. [9]Primarily thyroid cancer. [10]Including leukemias which are coded as local cancers at the Cancer Registry of Norway. [11]Including CNS tumors and around 60% of the lymphomas for which no stage is recorded as well as cancers not otherwise specified (nos).

Results from stratified analyses are portrayed in Table 4. Stratifying the children by the educational level of their mothers (high, *i.e.*, above high school level, *versus* low, *i.e.*, high school level or below) resulted in a statistically significant advantage of 22% of being an only child for children with mothers with a low educational level. However, this was not observed for children with mothers with a high education. A nonsignificant protective effect was also suggested for children with married mothers with a high education.

When stratifying the children by having sibling(s) *versus* being an only child, similar results were obtained. The mother's educational level was unimportant for children who had cancer and no siblings. However, children who had cancer and also sibling(s) at time of diagnosis had a 21% lower death probability if their mothers had a high education.

For children with cancers that require long-term treatments, having no siblings or better-educated mothers was associated with a statistically significant mortality advantage of approximately 18–19%. This relationship was present but not significant for those with other cancers. A mortality disadvantage of 42% was observed for the oldest children with chronic cancers, whereas an advantage was seen for other cancers in this age group.

The protective effect of higher education of mothers was similar across the diagnostic periods, whereas the advantageous effect of being an only child was statistically significant only for children diagnosed in the early period (Table 4).

Discussion

This large registry-based study shows that survival after childhood cancer depends on the family's resources: mortality was reduced by approximately 15–20% for children without siblings and children whose mothers have tertiary education. However, stratified analyses suggest that these effects are

Table 4. A child's death probability stratified according to mother's educational level, number of siblings, the expected chronicity of treatment and adverse long-term effects, and diagnostic period[1]

	Educational level of mothers				Siblings at diagnosis				Chronic or resolving disease				Diagnostic period			
	Low education[2]		High education[3]		No siblings[4]		Siblings[5]		Chronic[6]		Resolving[7]		Before 1990		During or after 1990	
	OR[8]	95% CI[9]	OR	95% CI	OR	95% CI	OR	95% CI	OR[4]	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Current calendar period																
1974–1979	2.26	1.78–2.88	2.34	1.21–4.50	1.69	0.90–3.19	2.42	1.90–3.08	2.02	1.53–2.66	3.26	2.22–4.77	2.48	1.95–3.16	N/A	N/A
1980–1984	1.56	1.25–1.94	2.22	1.31–3.75	1.37	0.78–2.41	1.70	1.36–2.11	1.47	1.14–1.89	2.29	1.63–3.22	1.72	1.38–2.15	N/A	N/A
1985–1989	1.24	1.01–1.52	1.44	0.88–2.37	1.26	0.75–2.13	1.27	1.04–1.56	1.19	0.95–1.51	1.51	1.09–2.08	1.26	1.01–1.58	N/A	N/A
1990–1994	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
1995–1999	0.83	0.66–1.03	1.21	0.76–1.91	1.02	0.60–1.70	0.87	0.70–1.07	0.92	0.72–1.16	0.84	0.60–1.19	0.66	0.35–1.23	0.95	0.74–1.21
2000–2007	0.61	0.49–0.77	0.95	0.60–1.52	0.61	0.36–1.03	0.69	0.56–0.86	0.62	0.48–0.79	0.84	0.60–1.17	<0.01	N/A	0.72	0.57–0.91
Age at diagnosis																
Child aged 0–4 years	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Child aged 5–9 years	1.11	0.94–1.31	0.97	0.68–1.38	0.91	0.60–1.38	1.10	0.93–1.30	1.12	0.95–1.33	0.82	0.61–1.11	1.01	0.82–1.23	1.13	0.91–1.41
Child aged 10–14 years	1.09	0.91–1.31	1.21	0.84–1.74	1.11	0.66–1.87	1.11	0.94–1.32	1.13	0.94–1.37	0.98	0.74–1.28	1.00	0.81–1.23	0.94	0.78–1.15
Child older than or equal 15 years	1.19	1.01–1.41	1.42	0.98–2.04	1.47	0.91–2.37	1.22	1.04–1.44	1.42	1.19–1.69	0.68	0.54–0.86	0.87	0.72–1.05	1.06	0.85–1.32
Marital status of parents[10]																
Married	1.04	0.91–1.19	0.86	0.65–1.14	1.16	0.85–1.59	0.99	0.87–1.13	0.96	0.83–1.11	1.03	0.84–1.26	0.95	0.82–1.11	1.04	0.87–1.24
Not married[11]	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
Number of siblings[10]																
0	0.78	0.64–0.94	0.93	0.65–1.33	N/A	N/A	N/A	N/A	0.81	0.66–0.99	0.83	0.61–1.13	0.70	0.55–0.88	1.01	0.79–1.29
1	1.00	ref	1.00	ref	N/A	N/A	N/A	N/A	1.00	ref	1.00	ref	1.00	ref	1.00	ref
≥2	0.98	0.87–1.11	0.86	0.66–1.11	N/A	N/A	N/A	N/A	0.91	0.79–1.05	1.11	0.92–1.33	0.94	0.82–1.07	1.04	0.88–1.24
Educational level of mothers[10]																
High school or less[11]	N/A	N/A	N/A	N/A	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref	1.00	ref
College and above	N/A	N/A	N/A	N/A	1.03	0.71–1.50	0.79	0.68–0.93	0.82	0.69–0.98	0.81	0.64–1.03	0.82	0.68–0.98	0.82	0.67–0.98

[1]All variables from the final model in Table 3 were included in the respective models, cancer form exempted (chronic/resolving cancers, time since diagnosis, earnings of parents and age of mothers not shown). [2]Low education refers to education at or below high school level and includes missing. [3]High education refers to any education beyond high school level. [4]No siblings at time of diagnosis. [5]One or more siblings at time of diagnosis. [6]Includes CNS tumors, leukemias (acute myelogenous leukemia excluded), neuroblastoma and bone cancers. [7]Includes the remaining cancer forms. [8]Odds ratio. [9]Confidence interval. [10]Refers to the situation at time of diagnosis. [11]Includes missing values.

restricted to cancers that involve long-term treatment. The earnings of parents seem to have no effect above and beyond education, and there is also no or minor impact of age or marital status of parents. Existing similar studies, based on smaller data sets for other countries, have not shown such a clear relationship between parental education and survival from childhood cancer,[2,5,7,26] but our results are in line with those from a recent, large Korean study.[9] No earlier investigation has addressed the possible importance of siblings. The lack of effect of marital status accords well with the literature. Income effects have been reported by some authors,[2,3] but comparison to studies from different countries is complicated due to dissimilar health care and welfare systems.

Effects of being an only child at the time of diagnosis

Stage at the time of diagnosis turned out to be relatively unimportant, and in principle, two main channels remain for the various sociodemographic factors to operate through in affecting cancer survival: treatment (the primary and follow-up treatment that is offered and the family's ability to make good use of it) and "host factors" (the child's health at the time of diagnosis and later health problems unrelated to the malignancy). The presence of siblings may have the consequence that the parents can devote less time to assisting the sick child, which could have effect through both pathways.[27] Although it may be the case that every child in Norway is offered the same cancer treatment, regardless of any personal initiatives from eager parents *vis-à-vis* the health personnel, mothers and fathers with additional family obligations might be less likely to comply with the recommended procedures for follow-up and less attentive to any unforeseen problems that they ideally should seek help for. When there are more children, there is also less to spend on each,[28] given the family income, but the lack of effect of the earnings of parents suggests that such economic factors are generally unimportant. It is also possible that having more siblings that compete for the time of parents increases the chance of comorbidities before or after diagnosis, though there is little evidence for such effects in developed countries. The above arguments are particularly relevant for cancers that require long-term treatment and thus develop into rather chronic health conditions. Thus, it is reasonable that we see the sharpest effects of the number of siblings in these instances.

Effects of the education of parents

The better survival among children with a better-educated mother, and thus also usually a better-educated father, may partly be the result of these parents having a higher level of health literacy, that is, being better able to communicate and interact with health care personnel and navigate the health care system. Furthermore, parents who have high education generally hold more flexible jobs that make it easier to spend time in hospitals with their children. All this may increase the chance of the child receiving adequate follow-up treatment. For similar reasons, children of better-educated parents may also have better health at diagnosis and thus avoid later comorbidities. Thus, it appears reasonable that the observed effects are sharpest for the cancers that require long-term treatment.

The lack of effect of earnings and marital status of parents

It would not be unreasonable to expect an effect of the income of parents, even within a public health care setting. Couples with higher incomes might, for instance, find it easier to reduce their working hours to provide extra care for their child, with implications for the child's follow-up treatment as well as the chance of avoiding comorbidities. Children from richer families may also have better health at time of diagnosis. However, the lack of effect suggests that these mechanisms on the whole are of little importance in Norway. The effect of marital status of parents, net of the other variables included in the model, might be expected to affect the survival largely through time constraints: To the extent that a child with unmarried parents lives with only one parent, there may be less time available to help and care for the child, in particular, if the other parent is less involved and/or supportive. This might seem to be an important factor in light of the previously discussed sibling effect. However, no effect is observed of marital status of parents, and the reason may be that most of the unmarried parents are cohabitants, or that also the nonresident parent contributes in case of a child's cancer illness.

Conclusion

The results from this large, registry-based study suggest that survival after childhood cancer depends in part on the resources of families. Time constraints and various noneconomic rewards of parents from their education appear to have an impact on childhood cancer survival. One reason may be that children of well-informed and strongly involved parents actually may be offered better initial and/or subsequent treatment, even within a universal health care setting with limited private alternatives and supposedly highly standardized treatment protocols in place.[7] Alternatively, such parents may be able to make better use of what is offered, for example, by following recommendations for out-patient follow-up care more closely.[29] It is also possible that their children are healthier at the outset, or that they are more likely to avoid later health problems that are unrelated to the malignancy but that weaken the survival prospects. Given the widely accepted idea that the health care system should reach well out to everyone and the suspicion that this perhaps is not quite the case after all, a careful analysis of possible treatment differentials using longitudinal directly measured treatment data should be welcome in future studies. Although a key concern would be that everyone is offered the same treatment, attention should also be given to the degree of compliance, as it might be argued that this is not solely an individual responsibility but resides within the domain of public policy. Should no such differences in treatment be revealed in future studies, the observed effects must be due to

differences in general health (behavior), which would indicate the need for health policy initiatives of a different type. It is obviously challenging to generalize to other settings and, in particular, with respect to the effects of economic resources. Presumably, they could be expected to be even more pronounced in most other countries with less generous health and welfare systems. Cross-national research on treatment decisions, health care delivery and utilization across social groups to further comprehend discrepancies in outcomes after childhood cancer appears warranted.

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