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Mark L. Greenberg, OC, MB, ChB, FRCPC
Mohammad Agha, PhD
Jason D. Pole, PhD
Paul C. Nathan, MD, MSc, FRCPC
David Hodgson, MD, MPH, FRCPC
Corin Greenberg, PhD

5

Health Service Utilization

Executive Summary

Health care service utilized by a population-based cohort of children diagnosed with cancer between 1995 and 2004 was analyzed using a database held by the Pediatric Oncology Group of Ontario, linked to a series of administrative databases held by the Institute for Clinical Evaluative Sciences (ICES). The cohort was followed until death or the end of the study period in December 2008.

Health service utilization was assessed using hospital admissions, length of stay, physician encounters and selected imaging studies as indicators. Comparisons were made to an age, gender and geographically matched control population.

Rate ratios for hospital admissions and length of stay were elevated many hundredfold for cases in the first month after diagnosis and remained so for up to 6 months after diagnosis. While there was subsequently a steady drop in the rate ratios, even 2 years after diagnosis these ratios were in excess of 50-fold and persisted at approximately 20-fold beyond 3 years from diagnosis. Patients with leukemia contributed the highest proportion of admissions and days of stay for the first 6 months, followed by those with lymphoma.

Rate ratios for physician encounters were similarly elevated in cases compared with controls, notwithstanding the systematic underestimation of physician services as a result of alternative payment plans (APPs).

Since these evaluations do not encompass use of diagnostic services and most imaging, they are a minimal estimate. The results indicate, however, the extraordinarily high consumption of health services, persisting over long periods, that is one of the hallmarks of a diagnosis of childhood cancer. Imaging use rate ratios for cases compared with controls for ambulatory computed tomography (CT) and magnetic resonance imaging (MRI) ranged from 1,500-fold in the first month to several hundredfold in the third year after diagnosis and 25-fold thereafter.

These results have the following policy implications:

- Childhood cancer cure rates are one of the most remarkable successes of contemporary medicine. However, the health care cost of success is enormous.
- Resource allocation for the management of this population must necessarily be intensified.
- Intensified resource allocation must encompass human resources in directly involved disciplines, but also in such disciplines as diagnostic imaging, pathology and pharmacy, among others.
- There is no clear end to the duration of increased health care utilization, so appropriate resources must stretch into the post treatment and survivorship period.
- Beyond the period of active treatment and follow up, childhood cancer survivors continue to use substantial health care resources that are not accounted for in resource allocation.

Introduction

The pattern of illness, and therefore care, in childhood cancer has a particular blend of acute and chronic characteristics. Patients may present critically ill or with large tumours, symptomatic in some but not all cases. Early interventions are of high intensity and result in high acuity of illness. Treatment in most cases stretches over prolonged periods and follows a pattern of repeated high, albeit variable, intensity interventions using varying combinations of surgery, chemotherapy, stem cell transplant and radiation.

In the most common childhood cancer, acute lymphoblastic leukemia, protracted ambulatory maintenance therapy is employed, with primary cancer therapy continuing for up to 3 years after diagnosis. During the course of active therapy, unscheduled ambulatory visits and hospital admissions often occur as a result of complications of the aggressive therapy. Ambulatory visits often involve consultation with multiple specialties and extensive use of diagnostic, laboratory and physiologic monitoring services.

Completion of therapy dramatically reduces health care utilization but demands intensive surveillance for recurrence in the first 2 to 3 years – for some cancers even longer. Even after the period of highest risk for recurrence is over, the pattern of health care utilization does not revert to that of the non-cancer population.

As described in several sections of this Atlas, survival rates for children with cancer have risen substantially over the past 2 decades[1,2]. This survival improvement is the result of better understanding of the use of combinations of treatment modalities, more rational use of combinations of chemotherapy agents and more intensive therapy enabled by better supportive care. These shifts in treatment intensity have produced corresponding demands on the health care system; this chapter describes some dimensions of that demand.

This chapter addresses health care utilization by children aged 0–14 years at diagnosis who were treated for cancer in Ontario between 1995 and 2004, with follow up to December 2008. This cohort was selected because detailed treatment data are available and correlation with health care utilization is possible. Health care utilization from the time of diagnosis until death or the end of the follow up period has been analyzed. A separate analysis of utilization from the time therapy is completed is also presented. These latter analyses of health care utilization by off-treatment subjects encompass a different timeframe from other published descriptions of utilization by survivors, which focus on survivors of childhood cancer beyond 2 years from completion of therapy.[3] While there may be some overlap, the period after completion of therapy is not further analyzed in this chapter.

For the purposes of this chapter, health care utilization has been defined as

- Hospital admissions and duration of stay (in days), expressed as rates per person time by time period after diagnosis
- Physician visits, including inpatient and ambulatory visits, but excluding emergency room visits
- Utilization rates for selected high intensity imaging studies for which billing data are available

The documentation of physician visits is based on physician billing to the Ontario Health Insurance Plan (OHIP). In the academic health science centres, "shadow billing" has been used for many years – the funding process is an APP but physicians are required to shadow bill to justify APP expenditure on physician services. Because physician reimbursement does not directly depend on billing, it is known that shadow billing substantially underestimates the actual number and type of services delivered, with variation over time and by centre because APPs were introduced at different times in different centres. Thus the quantification of physician visits is considered a substantial underestimate of utilization, amplified by the fact that the majority of physician visits for the control population are actual billings for services delivered outside the academic health centre environment, tending to reduce the rate ratio.

Since rules governing billing for diagnostic imaging have varied over time depending on whether the imaging is conducted in the ambulatory or inpatient setting, only diagnostic imaging services for which allowable billing is consistent over the timeframe of the analysis were analyzed.

A further contribution to underestimation of actual service use relates to the observation made above that an ambulatory visit almost always involves substantial use of diagnostic, laboratory and physiologic monitoring services, which represent health care utilization but are funded through hospital global budgets and thus are not billed and cannot be tracked.

Analyses that focus on health care utilization during the period of active therapy include all cases newly diagnosed in the study period irrespective of subsequent disease status. This dataset is analyzed from the time of primary diagnosis to time of death or the end of the follow up period, broken down by month for the first 6 months and then by 6 month periods until more than 3 years from primary diagnosis. It should be noted that the date of diagnosis is defined in the Pediatric Oncology Group of Ontario Networked Information System (POGONIS) database as "the date when definitive procedure confirming the diagnosis was carried out." For patients with solid tumours, including the central nervous system (CNS) group, a clinical diagnosis may have been made several days or more prior to this definitive procedure, and investigations, including diagnostic imaging, initiated. Such investigations would not have been captured since the starting point for the identification of health service utilization is the date of diagnosis. Similarly, days of hospitalization would have been systematically underestimated in this group. Thus all measures of utilization may be systematically underestimated, particularly with respect to inpatient stays.

Furthermore, significant delays in initial diagnosis in the primary care context and referral to the tertiary centre have been documented in the literature in a proportion of cases.[4–6] During this period, increased health care service utilization as a result of multiple visits and substantial use of diagnostic services, including extensive and costly use of imaging, laboratory and pathology resources, has often occurred. Such utilization prior to referral is not quantified in this chapter, thereby further underestimating true health care utilization.

The utilization for the period after completion of therapy is categorized monthly for the first 6 months to highlight immediate post therapy use and then by 6 month blocks until 24 months, yearly from 25 to 36 months and total visits beyond 36 months to the end of the follow up period. Completion of therapy is defined as a confirmed entry in the database indicating the end date of therapy. A small proportion of cases did not have a therapy end date, implying that they remained on therapy at the end of the follow up period and may thus have relapsed, or that they had died prior to the end of therapy.

Over the period analyzed, 20–25% of identified patients would have relapsed, either on treatment or after completion of treatment. A further, relatively small, number would have developed a second primary cancer. Health care utilization beyond 2 years from original diagnosis in these subgroups will be significantly higher but has been included in these analyses.

It is self-evident that children with chronic disease will use health care disproportionately compared with those without chronic disease. Data for health care utilization for chronic disease with episodic patterns of acute illness, such as asthma, demonstrate a substantial increase in hospitalization rates and ambulatory visits, albeit declining over the decades.[7] Data for children in Alberta with diabetes demonstrate 2.4 times the number of total physician visits in the youngest age group (aged < 5 years), compared with the equivalent age group in the general population, dropping to 1.5 and 1.8 times in the 5–9 year old and 10–14 year old groups, respectively.[8] Data for children with a developmental disability[9] also demonstrate substantial differences in hospital days compared with the general population (464 vs. 55 days per 1,000 population), non-physician professional visits (3.0 vs. 0.6) and home health provider days (3.8 vs. 0.04). In contrast to children with cancer, the highest consuming 10% of children with disabilities accounted for 65% of the total health care expenses of the cohort.

Patterns of care in all these categories differ from those in childhood cancer, however. Thus, we wished to identify how and to what degree patterns of health care utilization by childhood cancer patients differ from those of the non-cancer population. For this purpose, the childhood cancer population has been matched 5:1 to a cohort of non-cancer patients, as described below. Health care utilization over an identical timeframe has been used for comparison. It is acknowledged that this control group contains children with other chronic diseases.

Methods

Datasets

The cohorts were assembled and data collected as follows:

- Data on all children resident in Ontario diagnosed with cancer at age less than 15 years between 1995 and 2004, including demographic, diagnosis, treatment, relapses and death information, was obtained from POGONIS.
- Information on hospital admissions was obtained from the Discharge Abstract Database of the Canadian Institute for Health Information (CIHI-DAD), regardless of where in Ontario the hospitalization took place. This database includes admission dates and the diagnoses and procedures coded on hospital discharge.
- Information on physician visits was obtained from the OHIP database. This database includes date of service provision, service provision code and physician type.
- The Registered Persons Database (RPDB) is Ontario's population-based health care registry, which provides basic demographic information (date of birth, date of death, address changes) about individuals who have ever received an Ontario Health Insurance Number (OHIN).

These databases were linked using, a unique identifier, the OHIN assigned to each individual by the Ontario Ministry of Health and Long-Term Care. OHINs are scrambled and all identifying information stripped in the research version of these databases.

The dataset assembled from POGONIS was securely transferred to the ICES and then linked with the RPDB. Linkage was performed using the child's OHIN, name, date of birth, gender, postal code at the time of diagnosis and, where necessary, a probabilistic record linkage. Linkage was achieved for 3,256 of the 3,267 cases in the dataset (greater than 99%). These linked cases constituted the cohort followed for health service utilization.

Controls were selected using the RPDB based on the following matching criteria: month and year of birth, gender and forward sortation area, which is the first 3 characters of a postal code. Up to 5 controls were selected using either all 4 matching criteria or, when that was not possible, matches based on the first 3 criteria; 15,771 controls were selected.

The cancer diagnosis date of each case was assigned to the case's matched controls as the starting point for follow up. In the event of death of the index case, the matched controls were censored on the date of death of the cancer case. Person years of follow up were calculated for all cases and their matched controls from the date of diagnosis until either the time of death, censuring date or end of follow up (December 31, 2008).

All cases and controls were then linked to the CIHI and OHIP databases using encrypted OHINs to collect data on all admissions to hospitals and physician visits during the follow up period. The CIHI database was used to obtain data on admission dates, discharge dates and length of stay. The OHIP database was used to obtain data on each physician service received.

The comparative analyses are expressed for all children with cancer, encompassing all categories in the International Classification of Childhood Cancer, version 3 (ICCC-3), and compared with all children who did not have cancer. To dissect the contribution of different cancer types, further analyses were conducted for 4 groups of disease categories within ICCC-3 – leukemia, lymphoma, CNS tumours and "other," which combines all other groups. These subset analyses are not compared with control populations.

Discussion

EXHIBIT 5.1a: **Hospital separation* rate (per person month) and rate ratio by time since diagnosis, for cases and matched controls, age 0–14 years, in Ontario, 1995–2004**

	Cases				Controls		
Time since diagnosis	No. of patients	No. of separations	Person years	Separation rate/month	No. of separations	Person years	Separation rate/month
1 month	3256	3903	268.97	1.21	83	1295.64	0.005
2 months	3208	3074	266.61	0.96	55	1285.17	0.004
3 months	3191	2801	265.00	0.88	33	1277.26	0.002
4 months	3171	2522	263.41	0.80	34	1269.74	0.002
5 months	3151	2265	262.08	0.72	35	1263.16	0.002
6 months	3138	1946	260.34	0.62	39	1254.55	0.003
7–12 months	3113	7178	1523.36	0.39	190	7342.23	0.002
13–18 months	2982	3493	1459.90	0.20	197	7033.92	0.002
19–24 months	2868	2335	1415.26	0.14	154	6825.81	0.002
25–36 months	2795	3478	2755.12	0.11	284	13285.47	0.002
More than 3 years	2719	4803	12813.02	0.03	1425	61872.60	0.002

All rates are calculated per month (even for periods longer than 1 month).
CI = confidence interval
*Hospital separation = number of cases discharged plus the number of inpatient deaths

EXHIBIT 5.1b: **Hospital stay rate* (per person month) and rate ratio by time since diagnosis, for cases and matched controls, age 0–14 years, in Ontario, 1995–2004**

	Cases				Controls		
Time since diagnosis	No. of patients	Stay days	Person years	Stay rate/month	Stay days	Person years	Stay rate/month
1 month	3256	30341	268.97	9.40	242	1295.64	0.02
2 months	3208	15927	266.61	4.98	163	1285.17	0.01
3 months	3191	13988	265.00	4.40	82	1277.26	0.01
4 months	3171	12501	263.41	3.95	72	1269.74	0.00
5 months	3151	11068	262.08	3.52	162	1263.16	0.01
6 months	3138	9462	260.34	3.03	123	1254.55	0.01
7–12 months	3113	30346	1523.36	1.66	667	7342.23	0.01
13–18 months	2982	14684	1459.90	0.84	548	7033.92	0.01
19–24 months	2868	9488	1415.26	0.56	387	6825.81	0.00
25–36 months	2795	14089	2755.12	0.43	1171	13285.47	0.01
More than 3 years	2719	21923	12813.02	0.14	5148	61872.60	0.01

All rates are calculated per month (even for periods longer than 1 month).
*Stay rate is based on total number of days patient was hospitalized during each admission. Stay lengths were added for multiple admissions during same period.
Stay rate = (total stay length for all patients during period) / (12 × total person years of follow up).
CI = confidence interval

Separation rate ratio	
Rate ratio	95% CI
226.52	182.26-281.53
269.42	206.36-351.74
409.11	290.26-576.62
357.55	254.91-501.54
311.90	223.37-435.52
240.45	175.13-330.14
182.09	157.66-210.30
85.43	74.01-98.61
73.13	62.12-86.08
59.05	52.33-66.65
16.28	15.34-17.27

Stay rate ratio	
Rate ratio	95% CI
603.94	532.18-685.38
471.01	403.66-549.59
822.21	661.77-1021.55
836.93	663.87-1055.10
329.29	281.97-384.54
370.70	310.30-442.87
219.28	203.09-236.77
129.10	118.55-140.60
118.24	106.82-130.90
58.02	54.66-61.58
20.56	19.95-21.20

Exhibits 5.1a and 5.1b

Not surprisingly, the separation rate, the term used for discharge (reflecting admission rate), is highest in the first month after diagnosis, with a mean of more than 1 admission per person month. The rate ratio compared with that of controls is strikingly high, with reasonable confidence intervals, limited by the low number of events in the control group. The separation rates drop slowly over the first 6 months, with rate ratios maintained at greater than 300-fold higher for virtually this entire period.

Similarly, the days of hospital stay (designated in this chapter as stay rate) is strikingly high, with a nearly 600-fold higher rate ratio in the first month. Hospital stay rates are dictated by the acuity of illness in this period. These rates drop steeply in the second and subsequent months, but remain substantially higher than for the control population in the first 6 months (rate ratio range, 329.3–836.9). The admission and stay rates comprise planned admissions for therapy and unplanned admissions for complications of therapy.

While the admission and stay rates decline consistently after 6 months, they remain elevated to 24 months after initiation of therapy and beyond. Between 25 and 36 months, when the majority of patients (excluding those with a diagnosis of acute lymphoblastic leukemia) have completed therapy, the rate ratio for separations is 59.1 and for stay rates, 58.0.

Even for the follow up period beyond 3 years after diagnosis (median subsequent follow up, 4.7 years), the rate ratio for admissions (16.3) and stays (20.6) remained elevated. Because cases who relapsed during this time were not excluded from this analysis, they may make some contribution to this elevation. Of surviving patients, 43.7% contributed to hospital stays and days beyond 3 years. The leukemia group had the highest proportion (55.3%) of survivors with late hospital stays and lymphoma (30.4%) the lowest (data not shown).

The rate ratio for separations and stay rates demonstrated no trend for change over the two 5 year periods (1995–1999 and 2000–2004) analyzed, so the data have been combined. A recent practice shift toward providing more chemotherapy in an outpatient setting rather than during a hospital admission occurred after the period analyzed.

EXHIBIT 5.2: **Hospital separation* and hospital stay rate† (per person month) by time since diagnosis, by diagnosis group, age 0–14 years, in Ontario, 1995–2004**

	Time since diagnosis	No. of separations	Stay days	Person years	Separation rate/month	95% CI	Stay rate/month	95% CI
Leukemia	1 month	1483	16231	87.68	1.41	1.34-1.48	15.43	15.19-15.66
	2 months	1359	7286	86.85	1.30	1.24-1.38	6.99	6.83-7.15
	3 months	1280	6524	86.58	1.23	1.17-1.30	6.28	6.13-6.43
	4 months	1036	5452	86.26	1.00	0.94-1.06	5.27	5.13-5.41
	5 months	933	4591	86.09	0.90	0.85-0.96	4.44	4.32-4.57
	6 months	713	3522	85.73	0.69	0.64-0.75	3.42	3.31-3.54
	7–12 months	2358	10250	503.90	0.39	0.37-0.41	1.70	1.66-1.73
	13–18 months	1382	6275	485.79	0.24	0.22-0.25	1.08	1.05-1.10
	19–24 months	1189	4913	473.10	0.21	0.20-0.22	0.87	0.84-0.89
	25–36 months	1982	7866	926.73	0.18	0.17-0.19	0.71	0.69-0.72
	More than 3 years	2236	12853	4394.10	0.04	0.04-0.04	0.24	0.24-0.25
Lymphoma	1 month	477	2681	28.91	1.38	1.25-1.50	7.73	7.44-8.03
	2 months	337	1703	28.60	0.98	0.88-1.09	4.96	4.73-5.20
	3 months	290	1270	28.48	0.85	0.75-0.95	3.72	3.52-3.93
	4 months	251	1164	28.33	0.74	0.65-0.84	3.42	3.23-3.63
	5 months	175	888	28.17	0.52	0.44-0.60	2.63	2.46-2.81
	6 months	111	646	28.12	0.33	0.27-0.40	1.91	1.77-2.07
	7–12 months	562	2681	164.94	0.28	0.26-0.31	1.35	1.30-1.41
	13–18 months	341	1636	161.39	0.18	0.16-0.20	0.84	0.80-0.89
	19–24 months	194	1253	158.84	0.10	0.09-0.12	0.66	0.62-0.69
	25–36 months	241	1297	308.32	0.07	0.06-0.07	0.35	0.33-0.37
	More than 3 years	332	1703	1382.92	0.02	0.02-0.02	0.10	0.10-0.11
Central nervous system tumours	1 month	516	3885	58.67	0.73	0.67-0.80	5.52	5.35-5.69
	2 months	217	1308	57.93	0.31	0.27-0.36	1.88	1.78-1.99
	3 months	178	1032	57.04	0.26	0.22-0.30	1.51	1.42-1.60
	4 months	225	1016	56.35	0.33	0.29-0.38	1.50	1.41-1.60
	5 months	231	1009	55.86	0.34	0.30-0.39	1.51	1.41-1.60
	6 months	248	965	55.05	0.38	0.33-0.43	1.46	1.37-1.56
	7–12 months	1185	4026	315.46	0.31	0.30-0.33	1.06	1.03-1.10
	13–18 months	602	2102	294.39	0.17	0.16-0.18	0.60	0.57-0.62
	19–24 months	235	796	283.28	0.07	0.06-0.08	0.23	0.22-0.25
	25–36 months	286	1062	553.99	0.04	0.04-0.05	0.16	0.15-0.17
	More than 3 years	875	2834	2667.72	0.03	0.03-0.03	0.09	0.09-0.09

All rates are calculated per month (even for periods longer than 1 month).
†Stay rate is based on total number of days patient was hospitalized during each admission. Stay lengths were added for multiple admissions during same period.
Stay rate = (total stay length for all patients during period) / (12 × total person years of follow up).
CI = confidence interval
*Hospital separation = number of cases discharged plus the number of inpatient deaths

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EXHIBIT 5.2: **Hospital separation* and hospital stay rate† (per person month) by time since diagnosis, by diagnosis group, age 0–14 years, in Ontario, 1995–2004** (cont'd)

	Time since diagnosis	No. of separations	Stay days	Person years	Separation rate/ month	95% CI	Stay rate/ month	95% CI
Other	1 month	1427	7544	93.70	1.27	1.20-1.34	6.71	6.56-6.86
	2 months	1161	5630	93.20	1.04	0.98-1.10	5.03	4.90-5.17
	3 months	1053	5162	92.90	0.94	0.89-1.00	4.63	4.50-4.76
	4 months	1010	4869	92.50	0.91	0.85-0.97	4.39	4.26-4.51
	5 months	926	4580	91.96	0.84	0.79-0.89	4.15	4.03-4.27
	6 months	874	4329	91.45	0.80	0.74-0.85	3.94	3.83-4.06
	7–12 months	3073	13389	539.05	0.48	0.46-0.49	2.07	2.03-2.11
	13–18 months	1168	4671	518.33	0.19	0.18-0.20	0.75	0.73-0.77
	19–24 months	717	2526	500.04	0.12	0.11-0.13	0.42	0.40-0.44
	25–36 months	969	3864	966.08	0.08	0.08-0.09	0.33	0.32-0.34
	More than 3 years	1360	4533	4368.28	0.03	0.02-0.03	0.09	0.08-0.09

All rates are calculated per month (even for periods longer than 1 month).
†Stay rate is based on total number of days patient was hospitalized during each admission. Stay lengths were added for multiple admissions during same period.
Stay rate = (total stay length for all patients during period) / (12 × total person years of follow up).
CI = confidence interval
*Hospital separation = number of cases discharged plus the number of inpatient deaths

Exhibit 5.2

Leukemia demonstrates the highest admission rate and by a large margin the highest stay rate in the first month, reflecting the intensity of initial therapy in this group of diseases. The leukemia group includes both myeloid and lymphoid leukemia, and hospital stays are known to be particularly long for the former. There is little difference between the other 3 groups in this first month. Both admission and stay rates for lymphoma are lower than those for leukemia, possibly reflecting the more frequent treatment of Hodgkin lymphoma in the ambulatory context.

Admission and stay rates generally remain higher for leukemia for the first 6 months than in the other 3 disease groups. Admission and particularly stay rates for CNS tumours are lower and decline more rapidly than those for lymphoma and other tumours, probably reflecting the ambulatory nature of therapy for a portion of this group of diseases. For all 3 groups (leukemia, lymphoma and CNS tumours), the admission and stay rates remain a log order higher than for the control group as a whole beyond 3 years from diagnosis (Exhibit 5.1). Of the leukemia population, 86% remained in the cohort beyond 3 years, as did 87% of the lymphoma population and 76% of the CNS population.

EXHIBIT 5.3a: **Hospital separation* rate (per person month) and rate ratio for cases completing primary therapy without relapse followed to death or end of study or censored at time of relapse† if no relapse after end of therapy, age 0–14 years, in Ontario, 1995–2004**

	Cases				Controls		
Time since end of treatment	No. of patients	No. of separations	Person years	Separation rate/month	No. of separations	Person years	Separation rate/month
1 month	2309	1133	186.89	0.505	44	917.01	0.004
2 months	2217	387	183.60	0.176	31	916.68	0.003
3 months	2189	340	181.73	0.156	20	916.60	0.002
4 months	2171	305	180.15	0.141	25	916.60	0.002
5 months	2154	266	178.89	0.124	14	916.60	0.001
6 months	2141	235	178.04	0.110	19	916.59	0.002
7–12 months	2130	861	1055.85	0.068	116	5499.10	0.002
13–18 months	2100	507	1045.77	0.040	107	5499.10	0.002
19–24 months	2088	313	1043.30	0.025	97	5499.03	0.001
25–36 months	2083	453	2079.48	0.018	171	10994.23	0.001
More than 3 years	2074	974	7851.58	0.010	807	42271.24	0.002

All rates are calculated per month (even for periods longer than 1 month).
Controls are censored at the same point as their matched cases (death, post therapy relapse or end of follow up).
†Relapsed cases contribute from the end of their primary therapy to the date of their relapse. If relapses occurred before completion of primary therapy, they are not included in this table.
CI = confidence interval
*Hospital separation = number of cases discharged plus the number of inpatient deaths

EXHIBIT 5.3b: **Hospital stay rate* (per person month) and rate ratio for cases completing primary therapy without relapse followed to death or end of study or censored at time of relapse† if no relapse after end of therapy, age 0–14 years, in Ontario, 1995–2004**

	Cases				Controls		
Time since end of treatment	No. of patients	Stay days	Person years	Stay rate/month	Stay days	Person years	Stay rate/month
1 month	2309	4717	186.89	2.103	78	917.01	0.007
2 months	2217	1714	183.60	0.778	73	916.68	0.007
3 months	2189	1357	181.73	0.622	61	916.60	0.006
4 months	2171	958	180.15	0.443	71	916.60	0.006
5 months	2154	968	178.89	0.451	53	916.60	0.005
6 months	2141	646	178.04	0.302	76	916.59	0.007
7–12 months	2130	2785	1055.85	0.220	439	5499.10	0.007
13–18 months	2100	1514	1045.77	0.121	383	5499.10	0.006
19–24 months	2088	765	1043.30	0.061	368	5499.03	0.006
25–36 months	2083	1180	2079.48	0.047	382	10994.23	0.003
More than 3 years	2074	2903	7851.58	0.031	369	42271.24	0.001

All rates are calculated per month (even for periods longer than 1 month).
Controls are censored at the same point as their matched cases (death, post therapy relapse or end of follow up).
*Stay rate is based on total number of days patient was hospitalized during each admission. Stay lengths were added for multiple admissions during same period.
Stay rate = (total stay length for all patients during period) / (12 × total person years of follow up).
†Relapsed cases contribute from the end of their primary therapy to the date of their relapse. If relapses occurred before completion of primary therapy, they are not included in this table.
CI = confidence interval

	Separation rate ratio	
	Rate ratio	95% CI
	126.35	93.49-170.75
	62.33	43.23-89.86
	85.74	54.62-134.60
	62.07	41.29-93.92
	97.35	56.88-166.63
	63.68	39.90-101.63
	38.66	31.85-46.93
	24.92	20.23-30.69
	17.01	13.54-21.36
	14.01	11.75-16.70
	6.50	5.92-7.13

	Stay rate ratio	
	Rate ratio	95% CI
	296.74	237.24-371.15
	117.23	92.75-148.17
	112.20	86.81-145.01
	68.65	53.95-87.37
	93.58	70.98-123.39
	43.76	34.50-55.50
	33.04	29.88-36.54
	20.79	18.58-23.25
	10.96	9.68-12.41
	16.33	14.55-18.33
	42.36	38.01-47.20

Exhibits 5.3a and 5.3b

Exhibits 5.3a and 5.3b depict the utilization pattern of patients whose course was not complicated by relapse and thus reflects a best case scenario. Patients who relapsed during their primary therapy are excluded and patients who relapsed after the end of therapy are censored at the time of their relapse. All others are followed to death or the end of the study period. The exhibits document hospital admission rates and stay rates beyond the end of therapy.

Both admission and stay rates are substantially higher than the rates for controls in the month after the end of therapy, reflecting the complications of the last cycle of chemotherapy or surgery as the final therapy. Rate ratios are greatly elevated – 126.4 and 296.7, respectively – although the confidence intervals are wide because of the smaller numbers of events. The rates then decline dramatically, but rate ratios remain significantly elevated even more than 3 years after the end of treatment – 6.5-fold for separation rate and 42.4-fold for stay rate. Median follow up duration is 3.6 years beyond the end of therapy.

EXHIBIT 5.4: **Hospital separation* and hospital stay rates† (per person month) for cases completing primary therapy without relapse by diagnosis and time since end of treatment followed to death or end of study or censored at time of relapse‡ if relapsed after end of therapy, age 0–14 years, in Ontario, 1995–2004**

	Time since end of treatment	No. of separations	Stay days	Person years	Separation rate/month	95% CI	Stay rate/month	95% CI
Leukemia	1 month	295	818	62.17	0.40	0.35-0.44	1.10	1.02-1.17
	2 months	118	524	61.34	0.16	0.13-0.19	0.71	0.65-0.78
	3 months	105	444	61.01	0.14	0.12-0.17	0.61	0.55-0.67
	4 months	98	260	60.69	0.13	0.11-0.16	0.36	0.31-0.40
	5 months	84	391	60.66	0.12	0.09-0.14	0.54	0.49-0.59
	6 months	73	264	60.47	0.10	0.08-0.13	0.36	0.32-0.41
	7–12 months	218	964	361.09	0.05	0.04-0.06	0.22	0.21-0.24
	13–18 months	121	526	358.59	0.03	0.02-0.03	0.12	0.11-0.13
	19–24 months	66	202	357.89	0.02	0.01-0.02	0.05	0.04-0.05
	25–36 months	90	387	714.85	0.01	0.01-0.01	0.05	0.04-0.05
	More than 3 years	258	740	2105.79	0.01	0.01-0.01	0.03	0.03-0.03
Lymphoma	1 month	75	352	21.67	0.29	0.23-0.36	1.35	1.22-1.50
	2 months	29	140	21.37	0.11	0.08-0.16	0.55	0.46-0.64
	3 months	30	147	21.25	0.12	0.08-0.17	0.58	0.49-0.68
	4 months	35	67	21.20	0.14	0.10-0.19	0.26	0.20-0.33
	5 months	37	96	21.17	0.15	0.10-0.20	0.38	0.31-0.46
	6 months	26	46	21.12	0.10	0.07-0.15	0.18	0.13-0.24
	7–12 months	113	434	126.51	0.07	0.06-0.09	0.29	0.26-0.31
	13–18 months	47	171	126.15	0.03	0.02-0.04	0.11	0.10-0.13
	19–24 months	25	127	126.01	0.02	0.01-0.02	0.08	0.07-0.10
	25–36 months	45	172	252.00	0.01	0.01-0.02	0.06	0.05-0.07
	More than 3 years	78	206	962.56	0.01	0.01-0.01	0.02	0.02-0.02
Central nervous system tumours	1 month	228	1404	35.94	0.53	0.46-0.60	3.26	3.09-3.43
	2 months	62	222	34.66	0.15	0.11-0.19	0.53	0.47-0.61
	3 months	46	222	33.92	0.11	0.08-0.15	0.55	0.48-0.62
	4 months	44	195	33.58	0.11	0.08-0.15	0.48	0.42-0.56
	5 months	40	164	33.18	0.10	0.07-0.14	0.41	0.35-0.48
	6 months	27	112	32.98	0.07	0.04-0.10	0.28	0.23-0.34
	7–12 months	116	448	190.91	0.05	0.04-0.06	0.20	0.18-0.21
	13–18 months	91	288	185.92	0.04	0.03-0.05	0.13	0.11-0.14
	19–24 months	41	102	185.52	0.02	0.01-0.02	0.05	0.04-0.06
	25–36 months	89	239	369.64	0.02	0.02-0.02	0.05	0.05-0.06
	More than 3 years	226	1103	1550.64	0.01	0.01-0.01	0.06	0.06-0.06

All rates are calculated per month (even for periods longer than 1 month).
†Stay rate is based on total number of days patient was hospitalized during each admission. Stay lengths were added for multiple admissions during same period.
Stay rate = (total stay length for all patients during period) / (12 × total person years of follow up).
CI = confidence interval
*Hospital separation = number of cases discharged plus the number of inpatient deaths
‡Relapsed cases contribute from the end of their primary therapy to the date of their relapse. If relapses occurred before completion of primary therapy, they are not included in this table.

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EXHIBIT 5.4: **Hospital separation* and hospital stay rates† (per person month) for cases completing primary therapy without relapse by diagnosis and time since end of treatment followed to death or end of study or censored at time of relapse‡ if relapsed after end of therapy, age 0–14 years, in Ontario, 1995–2004** (cont'd)

	Time since end of treatment	No. of separations	Stay days	Person years	Separation rate/month	95% CI	Stay rate/month	95% CI
Other	1 month	535	2143	67.68	0.66	0.60-0.72	2.64	2.53-2.75
	2 months	178	828	66.81	0.22	0.19-0.26	1.03	0.96-1.11
	3 months	159	544	66.13	0.20	0.17-0.23	0.69	0.63-0.75
	4 months	128	436	65.25	0.16	0.14-0.19	0.56	0.51-0.61
	5 months	105	317	64.47	0.14	0.11-0.16	0.41	0.37-0.46
	6 months	109	224	64.05	0.14	0.12-0.17	0.29	0.25-0.33
	7–12 months	414	939	380.60	0.09	0.08-0.10	0.21	0.19-0.22
	13–18 months	248	529	377.89	0.05	0.05-0.06	0.12	0.11-0.13
	19–24 months	181	334	376.38	0.04	0.03-0.05	0.07	0.07-0.08
	25–36 months	229	382	747.12	0.03	0.02-0.03	0.04	0.04-0.05
	More than 3 years	412	854	3275.58	0.01	0.01-0.01	0.02	0.02-0.02

All rates are calculated per month (even for periods longer than 1 month).
†Stay rate is based on total number of days patient was hospitalized during each admission. Stay lengths were added for multiple admissions during same period.
Stay rate = (total stay length for all patients during period) / (12 × total person years of follow up).
CI = confidence interval
*Hospital separation = number of cases discharged plus the number of inpatient deaths
‡Relapsed cases contribute from the end of their primary therapy to the date of their relapse. If relapses occurred before completion of primary therapy, they are not included in this table.

Exhibit 5.4

CNS tumours and the "other tumours" group have higher late admission and stay rates than the other disease groups, particularly in the first month after completion of therapy but maintained over the first 4 months. For all disease groups, the admission and stay rates appear to be a log order greater, even at the longest follow up time, than the rates for the entire control population used to generate Exhibits 5.3a and 5.3b.

An analysis of separation and stay rates for cases of acute lymphoblastic leukemia who relapsed, compared with rates for age matched leukemia patients who did not relapse, demonstrates significant elevation, most notably in the first 6 months after relapse but persisting until 24 months from relapse (data not shown).

EXHIBIT 5.5: **Ontario Health Insurance Plan service rate* (per person month) by time since diagnosis, for cases and controls, age 0–14 years, in Ontario, 1995–2004**

	Cases			Controls				
Time since diagnosis	No. of OHIP services	Person years	Service rate/month	No. of OHIP services	Person years	Service rate/month	Service rate ratio	95% CI
1 month	102459	268.97	31.74	8387	1295.64	0.54	58.8	57.55-60.17
2 months	57785	266.61	18.06	7998	1285.17	0.52	34.8	34.02-35.65
3 months	47793	265.00	15.03	7737	1277.26	0.50	29.8	29.07-30.50
4 months	42488	263.41	13.44	7730	1269.74	0.51	26.5	25.86-27.14
5 months	39129	262.08	12.44	8055	1263.16	0.53	23.4	22.86-23.98
6 months	36021	260.34	11.53	8021	1254.55	0.53	21.6	21.12-22.17
7–12 months	147635	1523.36	8.08	44262	7342.23	0.50	16.1	15.91-16.25
13–18 months	96605	1459.90	5.51	41716	7033.92	0.49	11.2	11.03-11.29
19–24 months	80262	1415.26	4.73	40296	6825.81	0.49	9.6	9.49-9.72
25–36 months	119906	2755.12	3.63	78041	13285.47	0.49	7.4	7.34-7.48
More than 3 years	344784	12813.02	2.24	547479	61872.60	0.74	3.0	3.03-3.05

OHIP = Ontario Health Insurance Plan
All rates are calculated per month (even for periods longer than 1 month).
*A service is a single service billed by a physician (or other health care professional entitled to bill OHIP).
CI = confidence interval

Exhibit 5.5

Physician visits, derived from OHIP service billings, are nearly 60-fold those of the control group in the first month after diagnosis. This difference reflects the acuity of illness and the frequent need for medical services. These encounters represent both inpatient and ambulatory contacts with physicians and are probably a substantial underestimate since inpatient shadow billing may be at least as erratic as outpatient billing.

The physician visit rate ratio does not diminish below a 10-fold elevation until beyond 18 months from diagnosis and remains 3 times that of controls until the end of the follow up period.

EXHIBIT 5.6: **Ontario Health Insurance Plan service rate* (per person month) by time since diagnosis, for cases, by diagnosis group, age 0–14 years, in Ontario, 1995–2004**

	Time since diagnosis	No. of OHIP services	Person years	Service rates/month	95% CI
Leukemia	1 month	43915	87.68	41.74	41.35-42.13
	2 months	24179	86.85	23.20	22.91-23.49
	3 months	18672	86.58	17.97	17.72-18.23
	4 months	16848	86.26	16.28	16.03-16.52
	5 months	15737	86.09	15.23	15.00-15.47
	6 months	13871	85.73	13.48	13.26-13.71
	7–12 months	55860	503.90	9.24	9.16-9.31
	13–18 months	40853	485.79	7.01	6.94-7.08
	19–24 months	37916	473.10	6.68	6.61-6.75
	25–36 months	56791	926.73	5.11	5.06-5.15
	More than 3 years	128099	4394.10	2.43	2.41-2.44
Lymphoma	1 month	13396	28.91	38.62	37.97-39.28
	2 months	8558	28.60	24.93	24.41-25.47
	3 months	6600	28.48	19.31	18.85-19.79
	4 months	5449	28.33	16.03	15.60-16.46
	5 months	4161	28.17	12.31	11.94-12.69
	6 months	3704	28.12	10.98	10.63-11.34
	7–12 months	15749	164.94	7.96	7.83-8.08
	13–18 months	11136	161.39	5.75	5.64-5.86
	19–24 months	9124	158.84	4.79	4.69-4.89
	25–36 months	12387	308.32	3.35	3.29-3.41
	More than 3 years	38525	1382.92	2.32	2.30-2.34
Central nervous system tumours	1 month	14776	58.67	20.99	20.65-21.33
	2 months	7268	57.93	10.46	10.22-10.70
	3 months	5470	57.04	7.99	7.78-8.21
	4 months	4678	56.35	6.92	6.72-7.12
	5 months	4460	55.86	6.65	6.46-6.85
	6 months	4208	55.05	6.37	6.18-6.57
	7–12 months	20381	315.46	5.38	5.31-5.46
	13–18 months	14281	294.39	4.04	3.98-4.11
	19–24 months	10024	283.28	2.95	2.89-3.01
	25–36 months	15817	553.99	2.38	2.34-2.42
	More than 3 years	67399	2667.72	2.11	2.09-2.12

OHIP = Ontario Health Insurance Plan
All rates are calculated per month (even for periods longer than 1 month).
*A service is a single service billed by a physician (or other health care professional entitled to bill OHIP).
CI = confidence interval

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EXHIBIT 5.6: **Ontario Health Insurance Plan service rate* (per person month) by time since diagnosis, for cases, by diagnosis group, age 0–14 years, in Ontario, 1995–2004** (cont'd)

	Time since diagnosis	No. of OHIP services	Person years	Service rates/month	95% CI
Other	1 month	30372	93.70	27.01	26.71-27.32
	2 months	17780	93.20	15.90	15.66-16.13
	3 months	17051	92.90	15.30	15.07-15.53
	4 months	15513	92.50	13.98	13.76-14.20
	5 months	14771	91.96	13.39	13.17-13.60
	6 months	14238	91.45	12.97	12.76-13.19
	7–12 months	55645	539.05	8.60	8.53-8.67
	13–18 months	30335	518.33	4.88	4.82-4.93
	19–24 months	23198	500.04	3.87	3.82-3.92
	25–36 months	34911	966.08	3.01	2.98-3.04
	More than 3 years	110761	4368.28	2.11	2.10-2.13

OHIP = Ontario Health Insurance Plan
All rates are calculated per month (even for periods longer than 1 month).
*A service is a single service billed by a physician (or other health care professional entitled to bill OHIP).
CI = confidence interval

Exhibit 5.6

The "front end loading" of physician encounters is observed in each diagnosis group. Surprisingly, the encounter rate for all other categories exceeds that for CNS tumours, with leukemia manifesting the most intense physician encounter rate, followed by lymphoma; this pattern persists throughout the entire follow up period. The physician encounter rate for CNS tumours drops faster and more profoundly from 3 to 6 months and then plateaus at a level comparable to that of leukemia and lymphoma. This pattern probably reflects the shorter duration of high intensity treatment during the period of the study, which largely precedes the introduction of multiple tandem hematopoietic stem cell transplants for medulloblastoma.

EXHIBIT 5.7: **Number and rate (per person month) of inpatient and outpatient computed tomography scans and outpatient magnetic resonance imaging scans, by time since diagnosis, for cases and matched controls, age 0–14 years, in Ontario, 1995–2004**

	Cases				Controls				
Time since diagnosis	No. of patients	No. of scans	Person years	Rate/ month	No. of scans	Person years	Rate/ month	Rate ratio	95% CI
1 month	3256	4645	268.97	1.44	14	1295.64	0.001	1598.23	1005.52-2857.28
2 months	3208	1904	266.61	0.60	28	1285.17	0.002	327.79	232.89-490.54
3 months	3191	1902	265.00	0.60	24	1277.26	0.002	381.98	264.84-591.46
4 months	3171	1747	263.41	0.55	11	1269.74	0.001	765.56	456.81-1483.61
5 months	3151	1333	262.08	0.42	23	1263.16	0.002	279.33	192.07-437.21
6 months	3138	1415	260.34	0.45	26	1254.55	0.002	262.26	183.99-399.11
7–12 months	3113	6926	1523.36	0.38	92	7342.23	0.001	362.84	298.33-450.10
13–18 months	2982	5405	1459.90	0.31	93	7033.92	0.001	280.02	230.36-347.06
19–24 months	2868	4285	1415.26	0.25	80	6825.81	0.001	258.33	209.43-325.89
25–36 months	2795	6348	2755.12	0.19	212	13285.47	0.001	144.39	126.47-166.27
More than 3 years	2719	14858	12813.02	0.10	2917	61872.60	0.004	24.60	23.65-25.60

All rates are calculated per month (even for periods longer than 1 month).
CI = confidence interval

EXHIBIT 5.8: **Number and rate (per person month) of inpatient and outpatient computed tomography scans and outpatient magnetic resonance imaging scans, by time since diagnosis, for cases by diagnosis group, age 0–14 years, in Ontario 1995–2004**

	Time since diagnosis	No. of patients	No. of scans	Person years	Rate/month	95% CI
Leukemia	1 month	1483	561	87.7	0.53	0.49-0.58
	2 months	1359	270	86.8	0.26	0.23-0.29
	3 months	1280	194	86.6	0.19	0.16-0.21
	4 months	1036	146	86.3	0.14	0.12-0.17
	5 months	933	127	86.1	0.12	0.10-0.15
	6 months	713	149	85.7	0.14	0.12-0.17
	7–12 months	2358	517	503.9	0.09	0.08-0.09
	13–18 months	1382	377	485.8	0.06	0.06-0.07
	19–24 months	1189	294	473.1	0.05	0.05-0.06
	25–36 months	1982	466	926.7	0.04	0.04-0.05
	More than 3 years	2236	1505	4394.1	0.03	0.03-0.03
Lymphoma	1 month	477	1043	28.9	3.01	2.83-3.20
	2 months	337	473	28.6	1.38	1.26-1.51
	3 months	290	469	28.5	1.37	1.25-1.50
	4 months	251	403	28.3	1.19	1.07-1.31
	5 months	175	298	28.2	0.88	0.78-0.99
	6 months	111	319	28.1	0.95	0.84-1.06
	7–12 months	562	1493	164.9	0.75	0.72-0.79
	13–18 months	341	1169	161.4	0.6	0.57-0.64
	19–24 months	194	854	158.8	0.45	0.42-0.48
	25–36 months	241	1195	308.3	0.32	0.30-0.34
	More than 3 years	332	1709	1382.9	0.1	0.10-0.11
Central nervous system tumours	1 month	516	1478	58.7	2.1	1.99-2.21
	2 months	217	326	57.9	0.47	0.42-0.52
	3 months	178	283	57	0.41	0.37-0.46
	4 months	225	304	56.3	0.45	0.40-0.50
	5 months	231	231	55.9	0.34	0.30-0.39
	6 months	248	252	55	0.38	0.34-0.43
	7–12 months	1185	1215	315.5	0.32	0.30-0.34
	13–18 months	602	963	294.4	0.27	0.26-0.29
	19–24 months	235	824	283.3	0.24	0.23-0.26
	25–36 months	286	1349	554	0.2	0.19-0.21
	More than 3 years	875	5074	2667.7	0.16	0.15-0.16

All rates are calculated per month (even for periods longer than 1 month).
CI = confidence interval

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EXHIBIT 5.8: **Number and rate (per person month) of inpatient and outpatient computed tomography scans and outpatient magnetic resonance imaging scans, by time since diagnosis, for cases by diagnosis group, age 0–14 years, in Ontario 1995–2004** (cont'd)

	Time since diagnosis	No. of patients	No. of scans	Person years	Rate/month	95% CI
Other	1 month	1427	1563	93.7	1.39	1.32-1.46
	2 months	1161	835	93.2	0.75	0.70-0.80
	3 months	1053	956	92.9	0.86	0.80-0.91
	4 months	1010	894	92.5	0.81	0.75-0.86
	5 months	926	677	92	0.61	0.57-0.66
	6 months	874	695	91.5	0.63	0.59-0.68
	7–12 months	3073	3701	539.1	0.57	0.55-0.59
	13–18 months	1168	2896	518.3	0.47	0.45-0.48
	19–24 months	717	2313	500	0.39	0.37-0.40
	25–36 months	969	3338	966.1	0.29	0.28-0.30
	More than 3 years	1360	6570	4368.3	0.13	0.12-0.13

All rates are calculated per month (even for periods longer than 1 month).
CI = confidence interval

Exhibits 5.7 and 5.8

Imaging utilization

The majority of imaging studies carried out on this patient population are undertaken at the tertiary hospitals. In this context, many categories of imaging studies are funded by the hospital's global budget and are not identified in the OHIP billing claims since no physician bill is submitted. However, data are available through OHIP for ambulatory and inpatient CT scans and ambulatory MRI studies. The data reveal a substantial number of such investigations in the first month following diagnosis, with rates exceeding 1 study per month per person year. The rate ratios are enormously elevated – approximately 1600-fold – in the first month after diagnosis, remaining several hundredfold higher until the 36th month and then dropping to 25 times higher until the end of follow up. Analysis by disease group indicates that the rates are substantially higher for CNS tumours, lymphoma and the "other" malignancy category, with rates 3- to 6-fold higher than those for leukemia in the first month. Importantly, these rates remain elevated in similar proportions even through the longest follow up period.

Summary

The pattern of illness and resultant care required in childhood cancer differs from other childhood conditions that demonstrate high rates of health care service utilization. Excellent survival rates have been achieved, but the use of health care services required to achieve those outcomes is intense.

The use of these services by a population-based cohort of children diagnosed with cancer between 1995 and 2004 was studied using a standardized database held by the Pediatric Oncology Group of Ontario, linked to a series of administrative databases. The cohort was followed until death or the end of the study period in December 2008. Indicators of utilization studied included hospital admissions and length of stay, physician encounters based on physician billing records and rates of selected high intensity imaging studies.

Rate ratios for admissions and hospital days for the cohort were calculated, comparing them to matched controls drawn from the general population. Rate ratios were many hundredfold higher in the first month after diagnosis and remained elevated several hundredfold for up to 6 months after diagnosis. While there was subsequently a steady drop in the rate ratios, even 2 years after diagnosis these ratios were in excess of 50-fold, and they persisted at approximately 20-fold beyond 3 years from diagnosis. The leukemia population contributes the highest proportion of admissions and stay days for the first 6 months, followed by lymphoma.

Physician visits are acknowledged to be systematically underestimated by virtue of APPs introduced into the academic health science centres during the period of study. Notwithstanding, the rate ratio for physician visits is 60-fold in the first month after diagnosis, remains markedly elevated at more than 20-fold for the first 6 months and is dramatically elevated until the end of the follow up period. The leukemia group again contributes the highest proportion of visits. The use of specialized imaging is elevated several hundredfold in the first months after diagnosis, peaking in the first month at nearly 1600-fold.

While other dimensions of health care utilization, such as pathology and laboratory services, could not be quantified for this analysis because they are funded by hospital global budgets and are not identifiable in administrative data, they are intensely used by this population.

Based on this analysis, the childhood cancer population uses vastly greater amounts of health service during active therapy. This pattern continues, albeit at lower intensity, over at least the duration of this study, which followed the cohort for a mean duration of 3.6 years beyond the end of therapy. The cohort represents a low volume but high cost group of children for whom treatment is enormously successful but very resource intensive. Provision of appropriate resources, human and material, both in the immediately related disciplines and in other supportive disciplines, is critical to the maintenance of these exceptional survival outcomes.

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Published by the Pediatric Oncology Group of Ontario (POGO)

Pediatric Oncology Group of Ontario
480 University Avenue, Suite 1014
Toronto, Ontario M5G 1V2
info@pogo.ca

Canadian cataloging in publication data:

Atlas of Childhood Cancer in Ontario
Includes bibliographical references.
ISBN: (Print) **978-0-9939255-0-4**
ISBN: (Online) **978-0-9939255-1-1**

How to cite this publication:

The production of *Atlas of Childhood Cancer in Ontario* was a collaborative venture. Accordingly, to give credit to individual authors, please cite individual chapters and title, in addition to editors and book title.

For example: Pole JD, Greenberg ML, Sung L, Agha M, Riehl, M. Survival. In: Greenberg ML, Barnett H, Williams J, editors. Atlas of Childhood Cancer in Ontario. Toronto: Pediatric Oncology Group of Ontario; 2015.

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