An Analysis of Hospital Costs for Childhood Cancer Care

Owen Tan, MComm¹; Deborah J. Schofield, PhD¹; and Rupendra Shrestha, PhD¹

ABSTRACT

Background: This study used a linked dataset consisting of all childhood cancers recorded over the course of 10 years in New South Wales (NSW), Australia, to evaluate the hospital and emergency department costs (from a payer perspective) and resources used by patients with childhood cancer. We also analyzed determinants responsible for high-frequency hospital admissions, hospital length of stay (LoS), and hospital costs. **Methods:** We analyzed linked data at the individual patient level for a retrospective cohort of 2,966 patients with cancer aged <18 years with a diagnosis date between 2001 and 2012 from the NSW Central Cancer Registry, Australia. We reported costs and use of hospitalization and emergency department presentation 1 year before the date of diagnosis, 1 year after diagnosis, and 2 to 5 years after diagnosis. We also examined the association between cancer types and hospital admission and hospital costs from the payer perspective. Patient characteristics associated with the frequency of hospital admissions, hospital LoS, and hospital costs were also determined using a generalized linear model. **Results:** Most hospital admission costs occurred in the first year after diagnosis, accounting for >70% of hospital costs within 5 years after diagnosis. The estimated median annual cost of hospitalization in the first year after diagnosis was A\$88,964 (interquartile range [IQR], A\$34,399–A\$163,968) for patients diagnosed at age 0 to 14 years and A\$23,384 (IQR, A\$5,585–A\$91,565) for those diagnosed at age 15 to 17 years. Higher frequency of hospital admissions, hospital LoS, and hospital costs were significantly associated with younger age at cancer diagnosis, cancer metastases, and living in remote/disadvantaged socioeconomic areas. **Conclusions:** Our study represents one of the first in Australia to include detailed hospitalization cost information for all childhood cancer cases. This study highlights the high hospital use by pediatric patients and the importance of early diagnosis. Our findings also demonstrate the health inequities experienced by patients from remote areas and the lowest socioeconomic areas.

J Natl Compr Canc Netw 2022;20(2):126–135
doi: 10.6004/jnccn.2020.7802

Background

Childhood cancers have been reported to use a disproportionate amount of healthcare resources in many countries.¹ The average cost of pediatric cancer hospitalization in 2009 was \$40,400 in the United States and was approximately 5 times higher than hospitalization for other pediatric conditions.² In Canada, the hospitalization cost of treating childhood cancer in 2012 was reported to be as high as CAD\$101,008 per patient (aged 0–14 years), and the total direct healthcare cost, including hospitalization cost, for the same period was CAD\$136,413.³ The Australian Institute of Health and Welfare (AIHW) reported that >80% of cancer costs in patients aged 0 to 14 years were attributable to their hospitalization costs.⁴ The 2013 AIHW report estimated total healthcare costs of cancer for children aged 0 to 14 years at A\$122 million, with hospitalization costs alone being approximately A\$103 million, in 2009. A recent report estimated that adolescent and young adult Australians diagnosed with cancer would incur a total cost of A\$1.3 million per person over their lifetimes, with hospital admission costs accounting for the largest component of health expenditure.⁵

However, previous studies of the hospitalization costs and use of childhood cancer care were often limited to certain types of cancer, had small sample sizes, or were dated.^{6,7} Two recent studies conducted in Canadian settings developed a comprehensive costing method by linking cancer registry and healthcare administrative data.^{3,8} Similarly, our study represents a rigorous approach to evaluating the cost of disease via data linkage and is one of the first to report detailed hospital and emergency department (ED) cost information for all childhood cancer cases recorded over 10 years in New South Wales (NSW), Australia. The aims of this study were to estimate the hospital and ED resources used by children (aged <18 years)^{9,10} diagnosed with cancer and to estimate hospital and ED costs of childhood cancer within 5 years of diagnosis from a payer perspective. The study also identifies key variables that are associated with high frequency of hospital admissions, hospital length of stay (LoS), and cost of hospital admissions.

See [JNCCN.org](https://www.jnccn.org) for supplemental online content.

¹GenIMPACT: Centre for Economic Impacts of Genomic Medicine, Macquarie Business School, Macquarie University, Sydney, Australia.

Methods

Data Source

The NSW Central Cancer Registry (CCR) contains records of people with cancer in NSW.¹¹ The study cohort comprised 2,966 patients aged <18 years who were registered in the NSW CCR¹¹ as being diagnosed with cancer between July 1, 2001, and December 31, 2012, which was the most recent date for which the data were available in the NSW CCR at the time of this analysis.

Each individual in the NSW CCR dataset was assigned a unique identifier by the Centre for Health Record Linkage,¹² and the data for these individuals were extracted from other datasets, including the NSW Registry of Births, Deaths & Marriages; NSW Cause of Death Unit Record File; NSW Admitted Patient Data Collection (APDC); and NSW Emergency Department Data Collection (see supplemental eTable 1, available with this article at JNCCN.org). The records were then linked based on the unique identifier for each patient.

Hospital Inpatient and ED Service Use

We analyzed the annual hospital LoS, annual number of emergency presentations, annual number of hospital admissions, cost of inpatient care, and cost of ED presentation by cancer type (Table 1¹³). Annual hospital LoS was estimated by summing the LoS for each admission in a year.

Hospital and ED Costs

Hospital treatment costs were estimated using Australian Refined Diagnosis Related Groups (AR-DRGs) and episode of care LoS. Cost estimates were obtained from the National Hospital Cost Data Collection estimates published by the Independent Hospital Pricing Authority for patients in public hospitals.¹⁴ For those in private hospitals, we used the Hospital Casemix Protocol average cost estimates for each AR-DRG.¹⁵ AR-DRGs is a system used to classify patient hospital admissions by connecting the number and type of patients treated in a hospital (known as *hospital case mix*) to the resources required by the hospital. Costs of ED presentation were estimated using the urgency-related group code from the NSW Emergency Department Data Collection.¹⁴

Based on data from the death registry, if a patient did not die within our analysis period, A\$0 cost was assigned for the period when no hospital or ED visits occurred. If a patient died within our analysis period, we limited the analysis of hospital and ED data for the individual up to the time of death. All costs were reported from a payer's perspective. Costs reported were inflated to 2018 using the consumer price index published by the Australian Bureau of Statistics (ABS).¹⁶

Geographic Location and Socioeconomic Status

The geographic distribution of patients was assessed using the Accessibility/Remoteness Index of Australia (ARIA+), which was used by the ABS for the Remoteness Area classification.¹⁷ Accordingly, our cohort was categorized by reported geographical area into 4 groups: major cities, inner regional, outer regional, and remote and very remote.

Patients' socioeconomic status was assessed using the Index of Relative Socio-economic Disadvantage (IRSD), one of the Socio-Economic Indexes for Areas (SEIFA) developed by the ABS to rank areas in Australia according to their relative socioeconomic advantage and disadvantage.¹⁸ The SEIFA IRSD measures relative disadvantage in specific geographical areas by assessing the proportion of the census population across multiple socioeconomic indicators. The SEIFA IRSD was then categorized into quintiles, with 1 being the least disadvantaged area and 5 being the most disadvantaged area.

Highest Degree of Spread Within 4 Months of Diagnosis

The highest degree of spread within 4 months of diagnosis estimated the extent of the spread of cancer from its point of origin within 4 months of the cancer diagnosis and was based on information collected from a combination of pathology reports, inpatient notifications, and other treatment facilities. The variable was categorized as localized to tissue of origin, regional spread, adjacent organs and/or regional lymph nodes, distant metastases, and hematologic cancer with undefined cancer spread.

Case Identification

Using date of diagnosis recorded in the NSW CCR, we categorized hospital inpatient records and ED presentations into 1 year before the date of diagnosis, within 1 year of the date of diagnosis, and within 2 to 5 years of the date of diagnosis (reported as an annual average over 4 years). Analysis for people in years 2 through 5 excluded those who died within 1 year of diagnosis.

Admissions with a cancer-related ICD-10, Australian Modification (ICD-10-AM) code¹⁹ or a cancer-related morphology code²⁰ as either the primary diagnosis or one of the secondary diagnoses were identified as cancer-related hospital admissions. Using cancer-related diagnosis codes to identify hospital admissions relevant to the disease was demonstrated to be an effective classification method in other studies.^{21,22}

We did not use ICD-10-AM codes to identify cancer-related ED presentations. The rationale for this approach was that, because of the heterogeneity in ED diagnosis coding, patients presenting at the ED often were not recorded with an ICD-10-AM cancer diagnosis code. All presentations within 5 years of the date of cancer diagnosis were considered in our analysis. Because of limited data

Table 1. NSW Central Cancer Registry Patient Characteristics

Characteristic	n (%)
Sex	
Male	1,639 (55.26)
Female	1,327 (44.74)
Age at diagnosis, y	
0–4	1,117 (37.66)
5–9	528 (17.80)
10–14	632 (21.31)
15–17	689 (23.23)
Number of primary cancer sites	
1	2,924 (97.66)
≥2	70 (2.34)
Highest degree of spread within 4 mo of diagnosis	
Localized to tissue of origin	867 (28.96)
Regional spread, invasion of adjacent organs and/or regional lymph nodes	264 (8.82)
Distant metastases	231 (7.72)
Hematologic cancer with undefined cancer spread	1,450 (48.43)
Nonhematologic cancer with unknown cancer spread	182 (6.08)
SEIFA	
Quintile 1 (least disadvantaged)	578 (19.49)
Quintile 2	583 (19.67)
Quintile 3	561 (18.93)
Quintile 4	603 (20.33)
Quintile 5 (most disadvantaged)	640 (21.57)
ARIA	
Major cities	2,159 (72.79)
Inner regional	602 (20.30)
Outer regional	190 (6.41)
Remote and very remote	15 (0.51)

(continued)

availability, analysis of ED presentations was limited to people diagnosed after 2005.

Reason for Hospital Admissions

Patients' hospital admissions were also reported by Major Diagnostic Categories (MDC). In the NSW APDC dataset, principal diagnoses were reported in 23 mutually exclusive MDC.²³ The diagnoses in each category are related to a single body system or etiology, roughly reflecting the specialty of care. Each category is partitioned according to whether a surgical procedure was performed. We subdivided the hospital admission records into cancer-related and non-cancer-related admissions as described in the preceding "Case Identification" subsection, and reported the distribution of principal diagnosis by MDC.

Table 1. NSW Central Cancer Registry Patient Characteristics (cont.)

Characteristic	n (%)
Cancer types	
Acute lymphoblastic leukemia	712 (23.78)
Brain	342 (11.42)
Hodgkin lymphoma	210 (7.01)
Non-Hodgkin lymphoma	186 (6.21)
Bone	177 (5.91)
Acute myeloid leukemia	168 (5.61)
Connective tissue, peripheral nerves	148 (4.94)
Kidney	134 (4.48)
Other endocrine glands	113 (3.77)
Melanoma of skin	106 (3.54)
Colon	70 (2.34)
Thyroid	68 (2.27)
Testis	67 (2.24)
Central nervous system	67 (2.24)
Ill-defined and unspecified site	60 (2.00)
Eye	59 (1.97)
Other lymphatic, hematopoietic	49 (1.64)
Liver	41 (1.37)
Ovary	41 (1.37)
Other myeloid leukemia	27 (0.90)
Other thoracic organs	20 (0.67)
All other cancer types	129 (4.31)

Abbreviations: ARIA, Accessibility/Remoteness Index of Australia; NSW, New South Wales; SEIFA, Socio-Economic Indexes for Areas. Data from NSW Central Cancer Registry.¹³

Outcome Measured, Reporting Cancer Types, and Statistical Analysis

We reported summary statistics (mean with standard deviation and median with interquartile range [IQR]) for frequency of annual hospital admissions, ED presentations per person, number of years spent in the hospital system (between the first cancer-related admission and the last cancer-related separation), annual hospital LoS, annual costs of hospital admissions, and ED presentations by cancer types (described in Table 1; for relevant ICD-O-3 codes, see supplemental eTable 2). Cancer types with <20 cases in the NSW CCR were grouped into "all other cancer types" (detailed in supplemental eTable 3). Because there were substantial differences in cancer distribution between younger and older age of diagnosis, we have included results separated into 2 age groups (0–14 and 15–17 years).

Age at diagnosis, sex, and advanced-stage cancer at diagnosis were reported by previous studies to influence childhood cancer survival rate.²⁴ Geographic distribution

Figure 1. Distribution of cancer types recorded in NSW CCR (2001–2012) by age group.

and socioeconomic status were also reported to be associated with survival in adult cancers.²⁵ Patient hospital stays were reported to be more prevalent in younger age groups.² Drivers of the number of hospital admissions and hospital LoS in the first year after cancer diagnosis were analyzed using a generalized linear model (GLM) with a log-link negative binomial distribution with the following variables: age at diagnosis, sex, highest degree of spread within 4 months of diagnosis, cancer types, number of primary sites (as defined in the International Rules for Multiple Primary Cancers),²⁶ ARIA+, SEIFA IRSD, and diagnosis year (2001–2012).

We used a similar modeling approach to analyze the drivers of hospital admission costs in the first year after diagnosis, using a GLM with a log-link gamma distribution with the same set of explanatory variables. All data analyses were performed using SAS 9.4 (SAS Institute Inc) and Microsoft Excel software.

Results

Among 2,966 patients with cancer (aged <18 years) in the NSW CCR, 55.3% were male (Table 1), and 27 had >1 record in the cancer registry (>1 primary cancer as defined by the Cancer Institute NSW).¹³ Acute lymphoblastic leukemia (ALL), brain cancer, Hodgkin lymphoma, non-Hodgkin lymphoma, and bone cancer together accounted for 55% of the reported cases (Figure 1). Among these cancers, ALL and brain cancer were more common among

the younger age group (0–4 years), whereas Hodgkin lymphoma and bone cancer were more common among the older age group (15–17 years). Non-Hodgkin lymphoma was most common in patients aged 10 to 14 years.

Most of the patients with cancer were from the major cities, closely aligning with the NSW population distribution by ARIA+. The childhood cancer cases were equally distributed among different socioeconomic groups, as represented by the SEIFA IRSD index (Table 1).

Most patients (97.7%) had 1 primary cancer site, and 29% were diagnosed with localized cancers (Table 1).

Hospital Admissions, ED Presentations, and Hospital LoS

A total of 62,771 records of hospital admissions were included in the NSW APDC dataset. Of those, 54,399 records fell within 5 years of cancer diagnosis and 48,090 were cancer-related admissions. A total of 23,450 records of ED presentations were included in the NSW Emergency Department Data Collection dataset, and 16,401 occurred within 5 years of cancer diagnosis.

Most hospital admissions and ED presentations occurred in the first year after diagnosis, accounting for 71% of hospital admissions and 50% of ED presentations in the 5 years after diagnosis with cancer (ages 0–14 years) (Table 2, supplemental eTable 4). Patients with ALL had the highest number of hospital admissions within 5 years of being diagnosed with cancer (25 per person; IQR, 20–33) (Table 2). ALL (7 per person; IQR, 2–12) and other

Table 2. Annual Frequency of Hospital Admissions per Patient

Parameter	1 y Before Diagnosis		1 y After Diagnosis		2-5 y After Diagnosis (Annually)		Total of Years 1-5 (Sum Over 5 y)	
	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)
Age at diagnosis								
0-14 y	0.00 (0.00-0.00)	0.04 (0.47)	12.00 (4.00-19.00)	13.05 (10.27)	0.75 (0.00-2.00)	1.79 (3.17)	17.00 (6.00-26.00)	18.76 (16.99)
15-17 y	0.00 (0.00-0.00)	0.03 (0.21)	3.00 (1.00-9.00)	6.12 (7.45)	0.00 (0.00-0.50)	0.88 (2.25)	4.00 (1.00-11.00)	8.30 (10.92)
By cancer type								
Acute lymphoblastic leukemia	0.00 (0.00-0.00)	0.01 (0.09)	19.00 (16.00-22.00)	18.87 (7.47)	1.25 (0.75-2.50)	2.39 (3.04)	25.00 (20.00-33.00)	27.10 (13.60)
Brain	0.00 (0.00-0.00)	0.06 (0.30)	6.00 (2.00-13.00)	8.79 (9.91)	0.75 (0.00-2.25)	1.65 (2.51)	8.00 (2.00-17.00)	12.62 (14.06)
Hodgkin lymphoma	0.00 (0.00-0.00)	0.01 (0.12)	4.00 (2.00-8.00)	5.73 (5.27)	0.00 (0.00-0.00)	0.28 (1.04)	5.00 (2.00-9.00)	6.81 (7.39)
Non-Hodgkin lymphoma	0.00 (0.00-0.00)	0.01 (0.07)	10.00 (4.00-14.00)	10.22 (8.12)	0.00 (0.00-0.75)	1.00 (2.40)	10.50 (5.00-17.00)	13.00 (12.14)
Bone	0.00 (0.00-0.00)	0.02 (0.18)	15.00 (6.00-22.00)	14.63 (9.98)	0.50 (0.00-2.50)	1.85 (3.03)	20.00 (7.00-28.00)	19.58 (14.31)
Acute myeloid leukemia	0.00 (0.00-0.00)	0.02 (0.15)	11.00 (8.00-15.00)	11.41 (6.69)	0.63 (0.00-2.50)	1.71 (2.64)	15.00 (9.00-21.00)	16.33 (11.70)
Connective tissue, peripheral nerves	0.00 (0.00-0.00)	0.01 (0.12)	10.50 (3.00-17.00)	12.34 (11.71)	0.25 (0.00-2.25)	2.04 (5.06)	12.50 (4.00-22.00)	17.54 (19.16)
Kidney	0.00 (0.00-0.00)	0.01 (0.09)	8.00 (4.00-13.00)	11.08 (14.13)	0.25 (0.00-1.25)	1.55 (4.74)	11.00 (5.00-18.00)	15.95 (29.06)
Other endocrine glands	0.00 (0.00-0.00)	0.03 (0.16)	15.00 (8.00-19.00)	15.09 (10.53)	1.50 (0.00-3.50)	2.76 (4.27)	21.00 (8.00-28.00)	22.39 (18.08)
Melanoma of skin	0.00 (0.00-0.00)	0.01 (0.10)	1.00 (0.00-1.00)	1.01 (1.08)	0.00 (0.00-0.00)	0.14 (0.72)	1.00 (0.00-2.00)	1.43 (2.54)
Colon	0.00 (0.00-0.00)	0.07 (0.60)	1.00 (0.00-1.00)	1.04 (1.00)	0.00 (0.00-0.00)	0.07 (0.49)	1.00 (0.00-1.00)	1.13 (1.15)
Thyroid	0.00 (0.00-0.00)	0.03 (0.17)	2.00 (2.00-3.00)	2.56 (2.04)	0.00 (0.00-0.25)	0.15 (0.27)	3.00 (2.00-3.00)	3.18 (2.61)
Testis	0.00 (0.00-0.00)	0.01 (0.12)	3.00 (1.00-9.00)	6.93 (8.72)	0.00 (0.00-0.25)	0.62 (2.03)	4.00 (1.00-14.00)	8.42 (10.14)
Central nervous system	0.00 (0.00-0.00)	0.52 (2.25)	3.00 (1.00-7.00)	5.39 (6.05)	1.25 (0.25-2.75)	1.95 (2.40)	9.50 (3.00-18.00)	12.52 (14.03)
Ill-defined and unspecified site	0.00 (0.00-0.00)	0.03 (0.26)	7.50 (2.00-17.50)	11.18 (10.54)	0.50 (0.00-2.50)	1.76 (2.49)	13.50 (3.00-24.50)	17.17 (16.41)
Eye	0.00 (0.00-0.00)	0.00 (0.00)	8.00 (4.00-14.00)	9.68 (7.80)	1.50 (0.00-3.50)	2.87 (3.57)	13.00 (6.00-31.00)	20.78 (19.66)
Other lymphatic, hematopoietic	0.00 (0.00-0.00)	0.27 (1.17)	2.00 (1.00-7.00)	5.65 (8.14)	0.00 (0.00-1.25)	1.10 (2.04)	2.00 (1.00-13.00)	9.73 (14.22)
Liver	0.00 (0.00-0.00)	0.02 (0.16)	13.50 (8.50-17.50)	13.68 (8.43)	0.25 (0.00-1.25)	0.89 (1.97)	14.00 (9.00-20.50)	16.53 (12.18)
Ovary	0.00 (0.00-0.00)	0.00 (0.00)	5.00 (1.00-8.00)	5.66 (5.13)	0.00 (0.00-0.00)	0.08 (0.33)	5.00 (1.00-8.00)	5.88 (5.29)
Other myeloid leukemia	0.00 (0.00-0.00)	0.04 (0.19)	4.00 (1.00-5.00)	3.74 (2.84)	0.25 (0.00-1.00)	0.75 (1.38)	4.00 (1.00-8.00)	6.19 (7.22)
Other thoracic organs	0.00 (0.00-0.00)	0.00 (0.00)	12.00 (6.50-24.00)	15.00 (10.05)	0.88 (0.25-3.00)	2.94 (4.05)	19.50 (10.50-30.00)	24.80 (21.81)
All other cancer types	0.00 (0.00-0.00)	0.05 (0.46)	4.00 (1.00-12.50)	9.25 (11.61)	0.00 (0.00-1.00)	1.09 (2.37)	6.00 (1.00-19.00)	12.84 (15.81)

Abbreviation: IQR, interquartile range.

endocrine gland cancers (including malignancy of adrenal gland and other endocrine glands and related structures; 7 per person [IQR, 2–11]) had the highest number of ED presentations over the course of 5 years (supplemental eTable 4).

The median total hospital LoS values within 5 years of cancer diagnosis were 61 days (IQR, 21–109 days) for patients diagnosed with cancer at 0 to 14 years of age and 14 days (IQR, 2–63 days) for those diagnosed at 15 to 17 years of age (Table 3). Patients with acute myeloid leukemia (AML) spent the most days in the hospital, with a median of 129.5 days (IQR, 83–182.5 days) in the 5-year period after diagnosis. The estimated average LoS per admission was 4.4 days (supplemental eTable 5).

The median number of years spent in the hospital system (between the first cancer-related admission and the last cancer-related separation) was 1.84 (IQR, 0.63–2.49) for patients diagnosed at 0 to 14 years of age, and 0.48 (IQR, 0–1.37) for those diagnosed at 15 to 17 years of age (supplemental eTable 6). Patients with cancer of the central nervous system had the longest time in the hospital system, with a median of 3.35 years (IQR, 0.59–4.37 years).

Costs of Hospital Admissions and ED Presentations

Most hospital admission costs occurred in the first year after diagnosis, accounting for >70% of hospital costs within 5 years after diagnosis (Table 4). The estimated median annual cost of hospitalization in the first year after diagnosis was A\$88,964 (IQR, A\$34,399–A\$163,968) for patients diagnosed at 0 to 14 years of age, and A\$23,834 (IQR, A\$5,585–A\$91,565) for those diagnosed at 15 to 17 years of age (Table 4). The median cost of ED presentations was A\$1,782 (IQR, A\$0–A\$4,902) per patient in the first year after diagnosis for patients diagnosed at 0 to 14 years of age (supplemental eTable 7).

Patients with AML had the highest cost of hospitalization per patient in the 5 years after diagnosis, at a cost of A\$239,218 (IQR, A\$140,434–A\$358,797) (Table 4). Patients with ALL had the highest ED costs per patient in the 5 years after diagnosis, at A\$5,467 (IQR, A\$1,854–A\$10,206) per patient (supplemental eTable 7). Total costs of all cancer-related hospital admissions and ED presentations were approximately A\$448 million over the 5-year period after cancer diagnosis for all patients in NSW during 2001 through 2012 (supplemental eTable 8).

Reason for Hospital Admission, by MDC

In the cancer-related hospital admission dataset, a substantial proportion (44%) of the admissions fell into the “neoplastic disorders” MDC (supplemental eTable 9). In the non-cancer-related hospital admission dataset, most admissions fell into the “factors influencing health status and other contacts with health services” MDC

(supplemental eTable 9). Some of the common ICD-10-AM codes related to this MDC in the dataset were Z45 (adjustment and management of drug delivery or implanted device) and Z50 (care involving use of rehabilitation procedures).

Drivers for Hospital Admissions and Costs in Year 1 After Diagnosis

Because most hospital admissions occurred in the first year after diagnosis, we analyzed drivers for year 1 hospital admissions, LoS, and costs by using a GLM. A higher frequency of hospital admissions in the first year after diagnosis was significantly associated with being male, younger age at cancer diagnosis, having highest cancer spread (regional or distant metastases) within 4 months of diagnosis, and living in a remote area (supplemental eTable 10). Children diagnosed with ALL were admitted more frequently than those with other cancers in the first year after diagnosis. We observed that patients living in the second least disadvantaged SEIFA IRSD and those living in the most disadvantaged SEIFA IRSD had fewer hospital admissions than those living in the least disadvantaged SEIFA IRSD.

Similarly, these variables were analyzed as predictors of hospital costs and hospital LoS. Higher hospital costs and longer hospital LoS were significantly associated with cancer diagnosis at a younger age, highest cancer spread (regional or distant metastases) within 4 months of diagnosis, and living in the most disadvantaged of the SEIFA IRSD areas (supplemental eTable 10). Having been diagnosed with either brain or bone cancer resulted in >2 times higher hospital costs than having been diagnosed with ALL (reference cancer type).

Discussion

Our study reported hospital and ED cost information for all childhood cancers diagnosed in NSW, Australia, from 2001 through 2012. Hospital and ED costs and use for many cancer types in our study have not been reported previously in Australia.

Using linked data from multiple data sources, this article provides robust estimates of the hospital resources used for treating childhood cancer in Australia. Analyzing linked data from multiple registries has been shown to be an improved method of estimating healthcare costs^{3,8,27} when compared with studies with small sample sizes or a limited observation period.

Our findings show that childhood cancer, although rare in occurrence, required extensive hospital system support, and for specific types of childhood cancer, such as AML, the total hospital LoS can be as long as 100 days in the first year after diagnosis. The average cost of hospital admission for all patients with cancer in the first year after diagnosis was significantly higher than the national

Table 3. Length of Hospital Stay, in Days, per Patient

Parameter	1 y Before Diagnosis		1 y After Diagnosis		2–5 y After Diagnosis (Annually)		Total of Years 1–5 (Sum Over 5 y)	
	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)
Age at diagnosis								
0–14 y	0.00 (0.00–0.00)	0.16 (3.68)	51.00 (16.00–84.00)	58.61 (51.16)	1.00 (0.00–4.75)	8.05 (19.32)	61.00 (21.00–109.00)	80.31 (78.39)
15–17 y	0.00 (0.00–0.00)	0.12 (1.78)	11.00 (2.00–50.00)	31.28 (42.72)	0.00 (0.00–1.00)	6.20 (18.14)	14.00 (2.00–63.00)	44.55 (63.56)
By cancer type								
Acute lymphoblastic leukemia	0.00 (0.00–0.00)	0.01 (0.19)	63.00 (48.00–86.00)	72.13 (40.19)	2.50 (1.00–7.50)	12.99 (26.03)	78.00 (58.00–136.00)	109.72 (82.30)
Brain	0.00 (0.00–0.00)	0.18 (1.18)	32.00 (8.00–74.00)	48.12 (48.81)	1.00 (0.00–6.75)	7.58 (16.91)	43.00 (13.00–85.00)	61.68 (65.15)
Hodgkin lymphoma	0.00 (0.00–0.00)	0.01 (0.12)	12.00 (4.00–22.00)	15.80 (16.36)	0.00 (0.00–0.00)	1.05 (3.79)	13.00 (4.00–25.00)	19.77 (24.05)
Non-Hodgkin lymphoma	0.00 (0.00–0.00)	0.01 (0.07)	54.00 (25.00–74.00)	57.69 (44.21)	0.00 (0.00–1.00)	6.10 (18.90)	59.00 (29.00–90.00)	69.58 (61.30)
Bone	0.00 (0.00–0.00)	0.03 (0.25)	73.00 (22.00–100.00)	68.27 (47.84)	1.25 (0.00–8.75)	8.88 (15.08)	86.00 (35.00–128.00)	90.82 (69.59)
Acute myeloid leukemia	0.00 (0.00–0.00)	0.20 (2.11)	100.50 (70.00–139.50)	102.51 (53.05)	1.00 (0.00–20.75)	14.39 (28.71)	129.50 (83.00–182.50)	136.17 (79.45)
Connective tissue, peripheral nerves	0.00 (0.00–0.00)	0.05 (0.50)	36.50 (14.00–73.00)	49.78 (46.84)	0.25 (0.00–5.00)	7.99 (18.34)	42.50 (15.00–89.00)	66.34 (70.65)
Kidney	0.00 (0.00–0.00)	0.02 (0.26)	26.00 (18.00–57.00)	44.77 (65.33)	0.25 (0.00–2.00)	4.75 (11.35)	35.50 (19.00–68.00)	56.96 (76.72)
Other endocrine glands	0.00 (0.00–0.00)	0.04 (0.23)	88.00 (32.00–142.00)	92.61 (67.44)	2.25 (0.00–10.00)	8.85 (16.96)	106.00 (38.00–177.00)	113.57 (82.93)
Melanoma of skin	0.00 (0.00–0.00)	0.01 (0.10)	1.00 (0.00–2.00)	2.08 (4.45)	0.00 (0.00–0.00)	0.94 (7.76)	1.00 (0.00–2.00)	3.58 (10.40)
Colon	0.00 (0.00–0.00)	2.43 (20.32)	2.00 (0.00–6.00)	6.11 (11.93)	0.00 (0.00–0.00)	1.02 (8.01)	2.00 (0.00–6.00)	7.26 (15.46)
Thyroid	0.00 (0.00–0.00)	0.03 (0.17)	5.00 (3.00–7.00)	7.22 (11.86)	0.00 (0.00–0.75)	0.43 (0.75)	5.50 (4.00–9.50)	8.94 (13.57)
Testis	0.00 (0.00–0.00)	0.01 (0.12)	9.00 (1.00–32.00)	21.94 (32.23)	0.00 (0.00–0.25)	2.18 (9.54)	14.00 (1.00–38.00)	26.13 (35.67)
Central nervous system	0.00 (0.00–0.00)	0.66 (2.70)	8.00 (2.00–17.00)	17.95 (31.10)	2.50 (0.25–4.75)	4.36 (6.72)	19.50 (6.00–36.00)	32.61 (43.03)
Ill-defined and unspecified site	0.00 (0.00–0.00)	0.15 (1.16)	40.50 (15.50–102.00)	59.10 (52.07)	0.50 (0.00–8.75)	8.03 (14.98)	56.50 (21.50–128.00)	83.30 (83.43)
Eye	0.00 (0.00–0.00)	0.00 (0.00)	13.00 (7.00–27.00)	17.37 (15.11)	1.50 (0.00–5.25)	3.90 (6.38)	18.00 (8.00–45.00)	32.07 (33.35)
Other lymphatic, hematopoietic	0.00 (0.00–0.00)	1.31 (6.66)	8.00 (1.00–21.00)	23.47 (37.43)	0.00 (0.00–1.50)	4.50 (11.15)	12.00 (2.00–33.00)	40.47 (68.54)
Liver	0.00 (0.00–0.00)	0.02 (0.16)	57.00 (37.00–77.50)	61.80 (36.44)	0.25 (0.00–1.25)	3.73 (13.16)	59.00 (37.00–89.00)	69.03 (48.65)
Ovary	0.00 (0.00–0.00)	0.00 (0.00)	16.00 (5.00–41.00)	26.68 (26.94)	0.00 (0.00–0.00)	1.76 (9.89)	16.00 (5.00–45.00)	30.49 (34.00)
Other myeloid leukemia	0.00 (0.00–0.00)	0.11 (0.58)	17.00 (3.00–67.00)	39.96 (43.74)	0.50 (0.00–6.75)	9.65 (27.23)	34.00 (5.00–81.00)	58.63 (71.01)
Other thoracic organs	0.00 (0.00–0.00)	0.00 (0.00)	41.50 (29.00–72.00)	58.45 (50.21)	1.75 (0.50–13.50)	8.45 (12.73)	63.00 (35.50–124.00)	80.85 (59.74)
All other cancer types	0.00 (0.00–0.00)	0.17 (1.34)	15.50 (3.00–71.50)	43.70 (52.94)	0.00 (0.00–2.00)	5.59 (16.57)	17.50 (3.50–81.50)	61.00 (82.20)

Abbreviation: IQR, interquartile range.

Table 4. Cost of Hospital Admission per Patient in 2018 Australian Dollars

Parameter	1 y Before Diagnosis		1 y After Diagnosis		2–5 y After Diagnosis (Annually)		Total of Years 1–5 (Sum Over 5 y)	
	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)
Age at diagnosis								
0–14 y	0 (0–0)	390 (8,295)	88,964 (34,399–163,968)	115,304 (111,623)	2,959 (0–11,936)	17,365 (41,728)	119,027 (44,603–214,904)	162,819 (162,946)
15–17 y	0 (0–0)	232 (3,649)	23,834 (5,585–91,565)	63,038 (92,950)	0 (0–2,487)	12,523 (38,053)	30,077 (6,812–123,812)	90,308 (135,465)
By cancer type								
Acute lymphoblastic leukemia	0 (0–0)	15 (242)	112,809 (77,626–163,171)	135,391 (97,218)	6,002 (2,565–17,780)	28,039 (55,817)	153,945 (101,258–276,550)	216,384 (176,992)
Brain	0 (0–0)	483 (2,719)	80,631 (29,971–159,561)	118,412 (132,587)	4,214 (0–17,767)	16,028 (31,039)	106,378 (32,775–206,305)	150,746 (161,454)
Hodgkin lymphoma	0 (0–0)	28 (256)	20,000 (7,975–41,860)	31,147 (38,089)	0 (0–0)	2,220 (9,382)	22,101 (9,038–49,428)	38,721 (52,165)
Non-Hodgkin lymphoma	0 (0–0)	71 (970)	83,234 (36,207–143,896)	110,167 (118,518)	0 (0–2,029)	14,438 (52,000)	96,546 (43,005–181,430)	137,362 (149,009)
Bone	0 (0–0)	93 (841)	134,146 (56,028–196,253)	132,032 (86,638)	2,562 (0–20,436)	18,041 (33,449)	173,238 (76,781–254,313)	177,630 (131,159)
Acute myeloid leukemia	0 (0–0)	225 (1,891)	173,596 (114,898–283,841)	195,065 (124,950)	3,252 (0–39,505)	30,045 (57,229)	239,218 (140,434–358,797)	268,115 (176,844)
Connective tissue, peripheral nerves	0 (0–0)	64 (557)	79,673 (25,309–147,303)	95,622 (84,611)	735 (0–10,591)	16,240 (45,973)	83,720 (32,187–173,369)	128,359 (132,751)
Kidney	0 (0–0)	22 (259)	56,437 (32,128–99,024)	86,092 (125,333)	648 (0–5,157)	8,464 (17,857)	71,931 (37,843–132,206)	108,553 (137,856)
Other endocrine glands	0 (0–0)	99 (766)	174,511 (54,204–233,323)	166,475 (128,052)	6,341 (0–21,016)	18,611 (32,196)	201,638 (80,387–313,496)	211,678 (158,560)
Melanoma of skin	0 (0–0)	12 (125)	2,240 (0–4,728)	4,712 (8,355)	0 (0–0)	1,696 (12,063)	2,364 (0–4,824)	8,023 (21,387)
Colon	0 (0–0)	5,430 (45,429)	7,418 (0–14,213)	12,956 (17,864)	0 (0–0)	880 (6,351)	7,418 (0–14,213)	14,149 (21,352)
Thyroid	0 (0–0)	47 (280)	18,076 (14,533–24,502)	24,600 (31,416)	0 (0–1,952)	1,360 (2,860)	22,340 (16,770–32,294)	30,039 (40,386)
Testis	0 (0–0)	33 (268)	12,818 (4,446–56,604)	41,911 (69,636)	0 (0–409)	4,488 (17,296)	16,575 (4,446–71,093)	50,829 (75,916)
Central nervous system	0 (0–0)	1,919 (6,322)	22,388 (11,237–47,513)	46,377 (78,381)	8,759 (978–18,372)	11,910 (12,508)	57,524 (24,833–123,408)	89,703 (93,518)
Ill-defined and unspecified site	0 (0–0)	328 (2,544)	110,350 (33,978–176,620)	113,038 (87,461)	1,583 (0–11,545)	13,230 (23,833)	118,998 (43,115–240,476)	155,301 (134,831)
Eye	0 (0–0)	0 (0)	36,665 (25,622–56,785)	43,027 (30,688)	3,832 (0–14,113)	11,378 (17,413)	56,369 (31,481–109,410)	86,361 (85,866)
Other lymphatic, hematopoietic	0 (0–0)	3,359 (15,208)	15,394 (7,047–48,640)	47,454 (74,770)	0 (0–8,776)	10,233 (27,655)	17,728 (7,047–105,785)	87,008 (158,728)
Liver	0 (0–0)	119 (764)	93,558 (59,275–143,468)	119,033 (101,722)	994 (0–4,869)	13,050 (52,128)	102,163 (61,264–162,347)	139,880 (129,826)
Ovary	0 (0–0)	0 (0)	28,750 (10,757–62,593)	41,131 (38,757)	0 (0–0)	3,499 (20,158)	28,750 (10,757–67,248)	48,560 (57,916)
Other myeloid leukemia	0 (0–0)	255 (1,323)	24,339 (9,221–179,247)	86,061 (101,061)	696 (0–8,593)	22,455 (59,600)	57,534 (12,441–235,245)	131,548 (145,341)
Other thoracic organs	0 (0–0)	0 (0)	100,557 (55,242–123,343)	119,445 (95,485)	5,853 (1,296–35,077)	16,711 (22,064)	133,897 (79,643–245,969)	167,776 (122,574)
All other cancer types	0 (0–0)	548 (5,575)	37,732 (11,585–126,099)	90,178 (124,769)	0 (0–5,237)	10,767 (29,576)	40,415 (12,577–167,510)	124,867 (171,361)

Abbreviation: IQR, interquartile range.

average annual per capita inpatient cost for children aged 0 to 19 years (range, A\$341–A\$5,910) in 2012 through 2013.²⁸

In NSW, LoS per hospitalization (4.4 days) among patients with childhood cancer was shorter than that reported in a 2009 US study, in which the average LoS was 12 days per hospitalization (supplemental eTable 5).² However, the patients in NSW might have been admitted more frequently than their US counterparts, because some of the procedures performed in Australian hospitals might also be performed in outpatient settings in the United States. The US study also reported that the most common childhood cancers that required hospitalization were leukemias and brain cancers.² In our study, we found that ALL had a higher annual number of hospital admissions (Table 2), which might be due to the patients' immunocompromised condition and complex treatment protocols that require comprehensive hospital services.²⁹

We identified several factors that could lead to more frequent hospital admissions. Factors that might suggest more severe or more complicated cases, including cancer metastasis within 4 months of diagnosis, were associated with more frequent hospital admissions (supplemental eTable 10). Patients living in remote areas were admitted to a hospital 1.6 times more often than those living in major cities. However, there was no statistically significant difference in year 1 LoS across all geographic distributions. Australians living in remote areas were reported to have less frequent access to nonhospital nonreferred attendances and to face the challenge of being unable to find specialists nearby.³⁰ Our findings might reflect the compensation mechanisms for lacking access to relevant specialists in remote areas.

A study in Canada found that, in 2012, costs were much higher for patients who died within 1 year of diagnosis.³ Similarly, another study in the United States reported that being diagnosed with a myeloid leukemia and death within 3 years of diagnosis were significant predictors of hospital charges.³¹ Consistent with other studies,^{32,33} we found that a diagnosis of AML incurred higher hospital costs (supplemental eTable 10). Factors that might suggest the severity of the case, including cancer metastasis within 4 months of diagnosis, were significantly associated with higher hospital costs. Early diagnosis of childhood cancers has been associated with better survival outcomes^{34,35} and also with reduced posttreatment comorbidities by avoiding more intense and more expensive treatment. Early diagnosis could be achieved through a combination of effective diagnosis by general practitioners³⁶ and the implementation of genomic sequencing into routine diagnostic procedure.³⁷

Hospital costs were 14% higher for patients living in the most disadvantaged SEIFA IRSD area compared

with those living in the least disadvantaged area (supplemental eTable 10), likely because of the higher disease burden associated with this cohort.³⁸ Similar to other studies,^{30,38,39} we report that lower socioeconomic status and geographic remoteness may lead to higher hospital cost and more frequent hospital admissions. Despite the development of first National Rural Health Strategy 25 years ago, remote and rural Australians still lack access to comprehensive healthcare services.⁴⁰ Recent improvement in the implementation of telehealth might prove to be a good platform with which to tackle this issue.⁴¹

Our study has some limitations. It is limited to the analysis of hospitalization and ED costs. Although our analysis accounts for the bulk of the cost of the disease, it does not include all other costs incurred beyond the hospital system, including prescription medicine, outpatient visits, allied health, access to community health services, and out-of-pocket expenses. Furthermore, our ED data were not available until 2005; therefore, ED costs incurred before 2005 were not reported (supplemental eTable 7).

Conclusions

This study highlights the high hospital service use of patients with childhood cancer and the importance of early diagnosis, with treatment of metastatic cancer being associated with higher treatment costs. Our findings also demonstrate the health inequities experienced by patients from remote and low socioeconomic status areas. Future research on spatial analysis of variations in health access by patients with cancer will provide further insights into the issue of health inequities.

Acknowledgments

We thank the Cancer Institute NSW, and the NSW Ministry of Health for access to the health data, the NSW Registry of Births Deaths and Marriages for providing access to mortality data, and the NSW Centre for Health Record Linkage for conducting record linkage. The Cause of Death Unit Record File (COD URF) is provided by the NSW Registry of Births Deaths and Marriages, NSW Coroner, and the National Coronial Information System.

Submitted March 26, 2020; final revision received December 23, 2020; accepted for publication December 23, 2020.

Published online August 6, 2021.

Author contributions: Study concept and design: All authors. Statistical analysis: Tan. Manuscript writing – original draft: Tan. Manuscript writing – review and editing: All authors. Final manuscript approval: All authors.

Disclosures: The authors have disclosed that they have not received any financial consideration from any person or organization to support the preparation, analysis, results, or discussion of this article.

Correspondence: Owen Tan, MComm, GenIMPACT: Centre for Economic Impacts of Genomic Medicine, Macquarie Business School, Macquarie University, Level 3, 4ER Eastern Road, Macquarie Park, NSW 2113, Australia. Email: owen.tan@mq.edu.au

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Supplemental online content for:

An Analysis of Hospital Costs for Childhood Cancer Care

Owen Tan, MComm; Deborah J. Schofield, PhD; and Rupendra Shrestha, PhD

J Natl Compr Canc Netw 2022;20(2):126–135

eTable 1: Details of Datasets and Percent of Patients in the NSW CCR With Matching Records in Other Linked Datasets

eTable 2: Reporting Categories of Cancer Groups

eTable 3: Cancer Types Included in “All Other Cancer Types”

eTable 4: Annual Frequency of Emergency Department Presentations per Patient

eTable 5: Average Length of Stay in Hospital, by Age at Diagnosis

eTable 6: Number of Years Spent in Hospital System

eTable 7: Cost of Emergency Department Presentation per Patient in 2018 Australian Dollars

eTable 8: Cost of Cancer-Related Hospital Admissions and Emergency Department Presentations in Australian Dollars

eTable 9: Principal Diagnosis of Hospital Admissions Within 5 Years of Being Diagnosed With Cancer

eTable 10: Variables Associated With Number of Hospital Admissions, Hospital LOS, and Cost of Hospital Admissions Within First Year of Cancer Diagnosis

eTable 1. Details of Datasets and Percent of Patients in the NSW CCR With Matching Records in Other Linked Datasets

Datasets	No. of Individuals	% of NSW Central Cancer Registry	Data Available
NSW Central Cancer Registry	2,966	100%	July 1, 2001–December 31, 2012
NSW Admitted Patient Data Collection	2,844	96%	July 1, 2001–March 31, 2017
NSW Emergency Department Data Collection	1,929	65%	January 1, 2005–March 31, 2017
NSW Registry of Births, Deaths & Marriages	541	18%	July 1, 2001–March 31, 2017
NSW Cause of Death Unit Record File	527	18%	July 1, 2001–December 31, 2015

Note: 96% of patients in the NSW Central Cancer Registry have a matching hospital admission record, and 65% of patients in the registry have a matching emergency department record.
Abbreviation: NSW, New South Wales.

eTable 2. Reporting Categories of Cancer Groups

Topology Groups	Cancer Types	ICD-O-3 Codes
Skin	C00 Lip	C00
	C43 Melanoma of skin	C44 and M872x–M879x
	C46 Kaposi's sarcoma	M914x
Head and neck	C012 Tongue	C01, C02
	C036 Mouth	C03–C06
	C078 Salivary glands	C07, C08
	C0910 Oropharynx	C09, C10
	C11 Nasopharynx	C11
	C123 Hypopharynx	C12, C13
	C14 Other oral cavity and pharynx	C14
	C301 Nose, sinuses, etc.	C30, C31
	C32 Larynx	C32
Eye	C69 Eye	C69
Upper gastrointestinal	C15 Esophagus	C15
	C16 Stomach	C16
	C17 Small intestine	C17
	C22 Liver	C22
	C234 Gallbladder	C23, C24
	C25 Pancreas	C25
Colorectal	C18 Colon	C18
	C1921 Rectum, rectosigmoid, anus	C19–C21
Respiratory	C334 Lung	C33, C34
	C378 Other thoracic organs	C37, C38
	C45 Mesothelioma	M905x
Bone and connective tissue	C401 Bone	C40, C41
	C479 Connective tissue, peripheral nerves	C47, C49
Breast	C50 Breast	C50
Gynecologic	C53 Cervix	C53
	C545 Uterus, body and NOS	C54, C55
	C567 Ovary	C56, C57.0–7
	C58 Placenta	C58
	C59 Other female genital organs	C51, C52, C57.8–9

(continued on next page)

eTable 2. Reporting Categories of Cancer Groups (cont.)

Topology Groups	Cancer Types	ICD-O-3 Codes
Urogenital	51 Prostate	C61
	52 Testis	C62
	5360 Other male genital organs	C60, C63
	548 Kidney	C64–C66, C68
	C67 Bladder	C67
Neurologic	C71 Brain	C71
	C72 Central nervous system	C70, C72
Thyroid/Endocrine	C73 Thyroid	C73
	C745 Other endocrine glands	C74, C75
Lymphohematopoietic	C81 Hodgkin lymphoma	M965x–M966x
	32 Non-Hodgkin lymphoma	M959x, M967x–M972x, M974x
	3890 Multiple myeloma	M973x, M976x
	710 Acute lymphoblastic leukemia	M9821
	719 Other lymphoid leukemia's	M9820, M9822–M9827, M994
	720 Acute myeloid leukemia	M9861
	729 Other myeloid leukemia	M9860, M9862–M9868, M987x–M988x, M9930, M9987
	74 Other specified leukemia's	M984x, M985x, M989x–M993x
	75 Unspecified leukemia's	M980x
	95 Other lymphatic hematopoietic	C42, C77, and M974x, M975x, M995x–M997x [excluding M9963]
	M96 Myelodysplasia	M998
Cancer unknown primary	C98 Undefined and unspecified site	C26, C39, C48, C76, C80

Note: Tabulation categories for cancer site were derived from ICD-O-3 topography site and morphology. The categorization was originally developed to allow consistent reporting of cancer registry data. "x" in the ICD-O-3 codes represents the numbers 0 through 9.

Abbreviation: NOS, not otherwise specified.

eTable 3. Cancer Types Included in "All Other Cancer Types"

Lip	Tongue	Mouth	Salivary gland
Nasopharynx	Other oral cavity and pharynx	Stomach	Small intestine
Rectum	Pancreas	Nose/Sinuses	Larynx
Lung	Breast	Cervix	Uterus
Other female genital organs	Prostate	Other male genital organs	Bladder
Multiple myeloma	Other lymphoid leukemias	Other specified leukemias	Unspecified leukemias
Myelodysplasia			

eTable 4. Annual Frequency of Emergency Department Presentations per Patient

Parameter	1 y Before Diagnosis		1 y After Diagnosis		2–5 y After Diagnosis (Annually)		Total of Years 1–5 (Sum Over 5 y)	
	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)
Age at diagnosis								
0–14 y	0.00 (0.00–0.00)	0.39 (0.90)	2.00 (0.00–6.00)	3.41 (4.02)	0.50 (0.00–1.25)	0.89 (1.23)	4.00 (1.00–9.00)	6.39 (6.79)
15–17 y	0.00 (0.00–0.00)	0.31 (0.79)	0.00 (0.00–2.00)	1.55 (2.50)	0.25 (0.00–0.75)	0.60 (1.03)	2.00 (0.00–5.00)	3.45 (4.92)
By cancer type								
Acute lymphoblastic leukemia	0.00 (0.00–0.00)	0.35 (0.80)	3.00 (0.00–7.00)	4.29 (4.38)	0.75 (0.25–1.50)	1.18 (1.39)	7.00 (2.00–12.00)	8.46 (7.82)
Brain	0.00 (0.00–0.00)	0.39 (0.86)	2.00 (0.00–4.00)	2.88 (3.49)	0.25 (0.00–1.00)	0.87 (1.27)	3.00 (1.00–7.00)	5.04 (5.80)
Hodgkin lymphoma	0.00 (0.00–0.00)	0.33 (0.81)	1.00 (0.00–3.00)	1.90 (2.63)	0.25 (0.00–0.50)	0.37 (0.64)	2.00 (0.00–5.00)	3.37 (4.35)
Non-Hodgkin lymphoma	0.00 (0.00–0.00)	0.46 (1.06)	2.00 (0.00–5.00)	3.04 (3.60)	0.25 (0.00–0.75)	0.66 (1.00)	4.00 (1.00–8.00)	5.27 (5.61)
Bone	0.00 (0.00–0.00)	0.22 (0.56)	1.00 (0.00–4.00)	2.24 (3.26)	0.25 (0.00–0.75)	0.61 (0.98)	2.00 (1.00–5.00)	4.05 (5.14)
Acute myeloid leukemia	0.00 (0.00–0.00)	0.36 (0.86)	3.00 (0.00–6.00)	3.71 (3.78)	0.50 (0.00–1.50)	1.03 (1.25)	5.00 (2.00–10.00)	7.08 (7.33)
Connective tissue, peripheral nerves	0.00 (0.00–0.00)	0.40 (1.10)	1.00 (0.00–4.00)	2.89 (4.05)	0.25 (0.00–1.00)	0.92 (1.57)	3.00 (1.00–9.00)	5.41 (6.35)
Kidney	0.00 (0.00–0.00)	0.33 (0.79)	3.00 (0.00–6.00)	3.52 (3.73)	0.25 (0.00–1.00)	0.63 (0.90)	5.00 (1.00–8.00)	5.66 (5.32)
Other endocrine glands	0.00 (0.00–1.00)	0.65 (1.09)	4.00 (0.00–7.00)	4.68 (4.96)	0.75 (0.13–1.75)	1.20 (1.54)	7.00 (2.00–11.00)	7.79 (6.84)
Melanoma of skin	0.00 (0.00–0.00)	0.19 (0.63)	0.00 (0.00–0.00)	0.37 (1.03)	0.25 (0.00–0.50)	0.52 (1.00)	1.00 (0.00–2.00)	2.35 (4.23)
Colon	0.00 (0.00–1.00)	0.70 (1.38)	1.00 (0.00–3.00)	1.84 (1.95)	0.25 (0.00–1.00)	0.59 (0.90)	3.00 (1.00–6.00)	4.14 (4.85)
Thyroid	0.00 (0.00–0.00)	0.24 (0.58)	0.00 (0.00–0.50)	0.54 (1.63)	0.00 (0.00–0.38)	0.31 (0.64)	1.00 (0.00–2.00)	1.78 (3.85)
Testis	0.00 (0.00–0.00)	0.18 (0.58)	0.00 (0.00–2.00)	1.48 (2.92)	0.25 (0.00–0.50)	0.48 (0.79)	2.00 (0.00–4.00)	3.01 (3.86)
Central nervous system	0.00 (0.00–0.00)	0.39 (0.94)	0.00 (0.00–2.00)	1.65 (2.46)	0.50 (0.25–1.00)	0.71 (0.84)	2.00 (1.00–6.00)	4.26 (4.62)
Ill-defined and unspecified site	0.00 (0.00–0.00)	0.28 (0.56)	1.00 (0.00–5.00)	2.95 (4.00)	0.50 (0.25–1.25)	0.81 (1.00)	3.00 (1.00–10.00)	5.84 (6.36)
Eye	0.00 (0.00–0.00)	0.32 (0.82)	1.00 (0.00–3.00)	1.78 (2.25)	0.25 (0.00–0.75)	0.54 (0.74)	2.00 (1.00–5.00)	3.85 (4.15)
Other lymphatic, hematopoietic	0.00 (0.00–0.00)	0.59 (1.38)	1.00 (0.00–3.00)	1.94 (3.04)	0.50 (0.25–1.00)	0.71 (0.79)	3.00 (2.00–6.00)	4.67 (4.46)
Liver	0.00 (0.00–1.00)	0.46 (0.84)	3.00 (0.00–7.00)	4.14 (4.10)	0.75 (0.00–1.13)	1.00 (1.45)	5.00 (2.00–13.00)	7.59 (8.06)
Ovary	0.00 (0.00–0.00)	0.15 (0.36)	1.00 (0.00–2.00)	1.85 (3.93)	0.00 (0.00–0.50)	0.46 (1.13)	2.00 (0.00–3.50)	3.68 (8.13)
Other myeloid leukemia	0.00 (0.00–0.00)	0.19 (0.48)	2.00 (0.00–3.00)	1.68 (1.49)	0.25 (0.00–1.25)	0.82 (1.24)	3.00 (1.00–6.00)	4.56 (5.09)
Other thoracic organs	0.00 (0.00–1.00)	0.75 (1.25)	4.00 (0.00–7.00)	4.22 (4.17)	0.38 (0.25–0.75)	0.74 (0.93)	6.00 (2.00–9.00)	6.67 (5.76)
All other cancer types	0.00 (0.00–1.00)	0.51 (1.02)	0.00 (0.00–3.00)	2.15 (3.24)	0.25 (0.00–0.75)	0.63 (0.98)	2.00 (0.00–6.00)	4.32 (5.45)

Abbreviation: IQR, interquartile range.

eTable 5. Average Length of Stay in Hospital, by Age at Diagnosis

Age at Diagnosis	Average (SD), d
All age groups	4.40 (9.86)
0–4 y	4.05 (9.67)
5–9 y	4.14 (9.27)
10–14 y	4.86 (9.49)
15–17 y	5.32 (11.62)

eTable 6. Number of Years Spent in Hospital System^a

	Median (IQR)	Average (SD)
Age at diagnosis		
0–14 y	1.84 (0.63–2.49)	1.78 (1.37)
15–17 y	0.48 (0.00–1.37)	0.97 (1.25)
By cancer type		
Acute lymphoblastic leukemia	2.05 (1.99–2.63)	2.33 (1.05)
Brain	1.02 (0.24–2.64)	1.53 (1.49)
Hodgkin lymphoma	0.46 (0.12–0.77)	0.69 (0.9)
Non-Hodgkin lymphoma	0.67 (0.32–1.69)	1.12 (1.12)
Bone	1.17 (0.75–2.72)	1.71 (1.32)
Acute myeloid leukemia	1.17 (0.52–2.29)	1.64 (1.42)
Connective tissue, peripheral nerves	1.14 (0.53–2.2)	1.48 (1.33)
Kidney	0.98 (0.61–1.67)	1.28 (1.08)
Other endocrine glands	1.58 (0.81–3.08)	1.88 (1.31)
Melanoma of skin	0 (0–0.15)	0.46 (1.12)
Colon	0 (0–0.09)	0.19 (0.64)
Thyroid	0.27 (0.12–1.61)	0.99 (1.28)
Testis	0.38 (0–1.05)	0.7 (0.87)
Central nervous system	3.35 (0.59–4.37)	2.72 (1.86)
Ill-defined and unspecified site	1.22 (0.17–2.86)	1.66 (1.52)
Eye	2.36 (1.18–3.78)	2.48 (1.53)
Other lymphatic, hematopoietic	0.63 (0–2.39)	1.47 (1.72)
Liver	0.86 (0.45–1.66)	1.24 (1.16)
Ovary	0.17 (0–0.68)	0.41 (0.52)
Other myeloid leukemia	0.85 (0–1.98)	1.39 (1.58)
Other thoracic organs	1.54 (0.9–3.12)	1.89 (1.43)
All other cancer types	0.86 (0.06–2.01)	1.37 (1.48)

Abbreviation: IQR, interquartile range.

^aBetween first cancer-related admission and last cancer-related separation.

eTable 7. Cost of Emergency Department Presentation per Patient in 2018 Australian Dollars

Parameter	1 y Before Diagnosis		1 y After Diagnosis		2–5 y After Diagnosis (Annually)		Total of Years 1–5 (Sum Over 5 y)	
	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)	Median (IQR)	Average (SD)
Age at diagnosis								
0–14 y	0 (0–0)	227 (580)	1,782 (0–4,902)	2,936 (3,407)	251 (0–804)	637 (1,006)	3,252 (787–7,469)	5,033 (5,520)
15–17 y	0 (0–0)	177 (480)	0 (0–1,750)	1,211 (2,061)	107 (0–369)	402 (759)	983 (0–3,351)	2,411 (3,598)
By cancer type								
Acute lymphoblastic leukemia	0 (0–0)	179 (440)	2,930 (0–6,395)	3,815 (3,738)	525 (128–1,217)	879 (1,122)	5,467 (1,854–10,206)	6,879 (6,320)
Brain	0 (0–0)	249 (597)	1,548 (0–3,881)	2,454 (2,981)	181 (0–818)	643 (1,071)	2,406 (622–5,382)	4,020 (4,820)
Hodgkin lymphoma	0 (0–0)	165 (397)	610 (0–2,072)	1,462 (2,119)	54 (0–255)	227 (467)	1,345 (0–3,403)	2,337 (3,382)
Non-Hodgkin lymphoma	0 (0–0)	268 (655)	1,824 (0–4,251)	2,518 (2,883)	128 (0–512)	467 (831)	2,846 (418–6,173)	4,043 (4,380)
Bone	0 (0–0)	119 (363)	533 (0–2,930)	1,902 (2,815)	117 (0–453)	475 (867)	1,446 (411–4,183)	3,251 (4,363)
Acute myeloid leukemia	0 (0–0)	223 (602)	2,837 (0–5,251)	3,170 (3,085)	338 (0–1,002)	713 (972)	3,739 (1,062–7,796)	5,472 (5,553)
Connective tissue, peripheral nerves	0 (0–0)	245 (792)	817 (0–3,414)	2,385 (3,550)	150 (0–611)	562 (1,047)	2,333 (214–6,021)	3,948 (4,883)
Kidney	0 (0–0)	220 (579)	2,472 (0–4,865)	2,994 (3,239)	167 (0–507)	426 (748)	3,538 (801–6,414)	4,395 (4,352)
Other endocrine glands	0 (0–710)	393 (679)	3,228 (0–6,411)	3,995 (3,921)	475 (36–1,410)	948 (1,408)	5,176 (1,829–9,721)	6,307 (5,424)
Melanoma of skin	0 (0–0)	85 (308)	0 (0–0)	205 (562)	0 (0–205)	292 (579)	249 (0–1,133)	1,304 (2,447)
Colon	0 (0–411)	341 (724)	983 (0–2,079)	1,337 (1,390)	103 (0–436)	316 (456)	1,745 (510–4,271)	2,563 (2,661)
Thyroid	0 (0–0)	150 (401)	0 (0–142)	300 (908)	0 (0–176)	166 (404)	371 (0–817)	962 (2,308)
Testis	0 (0–0)	97 (296)	0 (0–1,317)	1,057 (2,250)	103 (0–263)	366 (788)	787 (0–2,578)	2,062 (2,992)
Central nervous system	0 (0–0)	214 (562)	0 (0–2,118)	1,370 (2,068)	258 (0–718)	516 (729)	1,351 (379–5,761)	3,261 (3,913)
Ill-defined and unspecified site	0 (0–0)	228 (512)	509 (0–3,806)	2,334 (3,243)	246 (103–953)	586 (825)	1,948 (625–6,356)	4,385 (5,132)
Eye	0 (0–0)	153 (388)	512 (0–2,180)	1,473 (1,982)	145 (0–357)	350 (556)	1,675 (411–4,315)	2,818 (3,566)
Other lymphatic, hematopoietic	0 (0–0)	406 (1,021)	724 (0–1,741)	1,663 (2,906)	244 (54–622)	442 (515)	1,741 (975–4,458)	3,361 (3,931)
Liver	0 (0–448)	256 (482)	3,352 (0–5,665)	3,371 (3,178)	360 (0–663)	711 (1,414)	3,352 (1,470–8,591)	5,832 (7,009)
Ovary	0 (0–0)	120 (322)	389 (0–1,264)	1,444 (3,311)	0 (0–225)	230 (601)	960 (0–2,296)	2,364 (5,488)
Other myeloid leukemia	0 (0–0)	166 (506)	1,625 (0–2,651)	1,568 (1,406)	185 (0–773)	565 (806)	2,911 (453–4,769)	3,558 (3,608)
Other thoracic organs	0 (0–503)	499 (1,082)	2,546 (0–6,202)	3,677 (3,949)	139 (71–401)	393 (580)	3,356 (710–7,857)	4,959 (5,072)
All other cancer types	0 (0–453)	324 (750)	0 (0–2,900)	1,843 (2,823)	110 (0–430)	447 (869)	1,443 (0–5,175)	3,329 (4,694)

Abbreviation: IQR, interquartile range.

eTable 8. Cost of Cancer-Related Hospital Admissions and ED Presentations in Australian Dollars

	Median Cost of Hospital + ED (IQR), A\$	Average Cost of Hospital + ED (SD), A\$
Age at diagnosis		
0–14 y	123,405 (46,407–221,804)	167,506 (165,517)
15–17 y	32,309 (8,676–125,958)	92,678 (136,890)
By cancer type		
Acute lymphoblastic leukemia	161,385 (106,321–283,967)	222,939 (179,406)
Brain	108,419 (35,090–208,907)	153,968 (163,358)
Hodgkin lymphoma	24,052 (9,610–51,336)	41,058 (53,213)
Non-Hodgkin lymphoma	101,724 (44,961–189,568)	141,319 (150,804)
Bone	174,408 (80,124–258,400)	180,808 (133,549)
Acute myeloid leukemia	242,376 (145,155–362,766)	273,261 (178,849)
Connective tissue, peripheral nerves	90,200 (36,116–180,537)	132,173 (135,001)
Kidney	75,388 (40,506–140,921)	112,915 (139,500)
Other endocrine glands	205,872 (82,092–323,625)	217,873 (161,241)
Melanoma of skin	2,611 (742–7,188)	9,327 (22,414)
Colon	11,030 (5,546–17,962)	16,675 (21,097)
Thyroid	22,979 (17,219–32,309)	31,002 (40,869)
Testis	20,425 (5,180–71,872)	52,891 (78,092)
Central nervous system	59,722 (25,244–130,620)	92,915 (95,019)
Ill-defined and unspecified site	124,685 (43,115–247,829)	159,540 (138,232)
Eye	58,650 (36,031–111,528)	89,180 (88,365)
Other lymphatic, hematopoietic	18,872 (10,205–106,665)	90,369 (160,847)
Liver	107,551 (57,391–164,642)	141,732 (132,501)
Ovary	28,750 (14,687–68,287)	50,866 (58,864)
Other myeloid leukemia	60,942 (17,682–238,169)	134,842 (145,448)
Other thoracic organs	136,402 (83,815–254,510)	172,239 (124,776)
All other cancer types	41,813 (13,307–168,170)	128,171 (174,662)
Total sum	447,802,210	

Total costs of all cancer-related hospital admissions and emergency department presentations were A\$448 million for the 5-year period after cancer diagnosis for all patients in New South Wales from 2001 through 2012. Costs are presented in 2018 Australian dollars.

Abbreviations: ED, emergency department; IQR, interquartile range.

eTable 9. Principal Diagnosis of Hospital Admissions Within 5 Years of Being Diagnosed With Cancer

Major Diagnostic Category	n (%)
Cancer-related admission	
Neoplastic disorders (hematologic and solid neoplasms)	21,096 (43.90)
Diseases and disorders of the musculoskeletal system and connective tissue	4,233 (8.81)
Infectious and parasitic diseases	3,681 (7.66)
Diseases and disorders of the nervous system	3,504 (7.29)
Diseases and disorders of the blood and blood-forming organs and immunologic disorders	3,471 (7.22)
Diseases and disorders of the kidney and urinary tract	1,687 (3.51)
Endocrine, nutritional and metabolic diseases and disorders	1,526 (3.18)
Diseases and disorders of the digestive system	1,512 (3.15)
Factors influencing health status and other contacts with health services	1,499 (3.12)
Diseases and disorders of the ear, nose, mouth and throat	1,187 (2.47)
Diseases and disorders of the respiratory system	1,133 (2.36)
Diseases and disorders of the eye	1,075 (2.24)
Diseases and disorders of the circulatory system	597 (1.24)
Diseases and disorders of the hepatobiliary system and pancreas	539 (1.12)
Diseases and disorders of the skin, subcutaneous tissue and breast	416 (0.87)
Diseases and disorders of the male reproductive system	343 (0.71)
Diseases and disorders of the female reproductive system	306 (0.64)
Injuries, poisoning and toxic effect of drugs	142 (0.30)
All other MDCs	113 (0.23)
Admission records without MDCs = 30	
Non-cancer-related admission	
Factors influencing health status and other contacts with health services	1,284 (20.46)
Diseases and disorders of the kidney and urinary tract	715 (11.39)
Diseases and disorders of the ear, nose, mouth, and throat	568 (9.05)
Diseases and disorders of the blood and blood-forming organs and immunologic disorders	528 (8.41)
Diseases and disorders of the digestive system	517 (8.24)
Infectious and parasitic diseases	392 (6.25)
Diseases and disorders of the musculoskeletal system and connective tissue	377 (6.01)
Diseases and disorders of the nervous system	324 (5.16)
Endocrine, nutritional, and metabolic diseases and disorders	322 (5.13)
Diseases and disorders of the respiratory system	311 (4.96)
Diseases and disorders of the skin, subcutaneous tissue, and breast	205 (3.27)
Diseases and disorders of the circulatory system	162 (2.58)
Injuries, poisoning, and toxic effect of drugs	122 (1.94)
All other MDCs	449 (7.16)
Admission records without MDC = 33	

Abbreviation: MDC, major diagnostic category.

eTable 10. Variables Associated With Number of Hospital Admissions, Hospital LoS, and Cost of Hospital Admissions Within First Year of Cancer Diagnosis

Parameter	No. of Hospital Admissions		Hospital LoS		Cost of Hospital Admission	
	Estimate	P Value	Estimate	P Value	Estimate	P Value
Intercept	3.57	.8799	0.00	.3125	0.00	.324
Age at diagnosis	0.97	<.0001	0.98	<.0001	0.98	<.0001
Sex		.038		.1078		.1538
Female	Ref		Ref		Ref	
Male	1.06	.0377	1.06	.1074	1.05	.1534
Highest degree of spread within 4 mo of diagnosis		<.0001		<.0001		<.0001
Localized	Ref		Ref		Ref	
Regionalized	1.23	.0002	1.68	<.0001	1.65	<.0001
Distant metastases	1.61	<.0001	2.21	<.0001	2.03	<.0001
Hematologic cancer/unknown spread	1.46	.0115	2.79	<.0001	2.69	<.0001
Cancer type		<.0001		<.0001		<.0001
Acute lymphoblastic leukemia	Ref		Ref		Ref	
Brain	0.73	.0482	1.82	.0017	2.22	<.0001
Hodgkin lymphoma	0.38	<.0001	0.25	<.0001	0.27	<.0001
Non-Hodgkin lymphoma	0.61	<.0001	0.86	.043	0.93	.305
Bone	1.34	.0722	2.68	<.0001	2.66	<.0001
Acute myeloid leukemia	0.63	<.0001	1.45	<.0001	1.49	<.0001
Connective tissue, peripheral nerves	0.83	.2467	1.30	.193	1.32	.1413
Kidney	0.69	.026	1.25	.2697	1.22	.2835
Other endocrine glands	0.78	.1396	1.90	.0017	1.89	.001
Melanoma of skin	0.10	<.0001	0.07	<.0001	0.12	<.0001
Colon	0.13	<.0001	0.32	<.0001	0.44	.0004
Thyroid	0.23	<.0001	0.23	<.0001	0.43	<.0001
Testis	0.58	.0026	0.63	.0332	0.64	.0271
Central nervous system	0.46	<.0001	0.79	.2814	1.00	.9899
Ill-defined and unspecified site	0.51	<.0001	0.73	.0113	0.78	.0266
Eye	0.63	.011	0.58	.0135	0.77	.2136
Other lymphatic, hematopoietic	0.28	<.0001	0.32	<.0001	0.36	<.0001
Liver	0.80	.2584	1.80	.0115	1.78	.0085
Ovary	0.46	<.0001	0.77	.2772	0.63	.0373
Other myeloid leukemia	0.22	<.0001	0.60	.0033	0.77	.1246
Other thoracic organs	0.80	.31	1.29	.3487	1.38	.2064
All other cancer types	0.64	.0003	1.04	.798	1.15	.3202
Number of primary cancer sites		.8569		.0692		.965
1	Ref		Ref		Ref	
≥2	1.02	.8661	1.31	.0782	1.01	.965
ARIA+ (patient's geographic remoteness)		.0794		.0448		.2338
Major cities	Ref		Ref		Ref	
Inner regional	0.99	.8661	0.89	.0085	0.93	.109
Outer regional	0.98	.6826	0.90	.1399	1.00	.9706
Remote and very remote	1.60	.0157	1.06	.8063	1.35	.2395

(continued on next page)

eTable 10. Variables Associated With Number of Hospital Admissions, Hospital LoS, and Cost of Hospital Admissions Within First Year of Cancer Diagnosis (cont.)

Parameter	No. of Hospital Admissions		Hospital LoS		Cost of Hospital Admission	
	Estimate	P Value	Estimate	P Value	Estimate	P Value
SEIFA-IRSD		.0004		.0684		.126
Quintile 1 (least disadvantaged)	Ref		Ref		Ref	
Quintile 2	0.89	.0095	1.04	.4969	1.08	.1309
Quintile 3	0.99	.7523	1.00	.9592	1.07	.2195
Quintile 4	1.01	.865	1.09	.1268	1.09	.0907
Quintile 5 (most disadvantaged)	0.87	.0015	1.14	.0171	1.14	.008
Diagnosis year	1.00	.857	1.01	.1818	1.01	.0335

Abbreviations: ARIA, Accessibility/Remoteness Index of Australia; IRSD, Index of Relative Socio-economic Disadvantage; LoS, length of stay; SEIFA, Socio-Economic Indexes for Areas.