HHS Public Access

Author manuscript

Cancer. Author manuscript; available in PMC 2019 January 15.

Published in final edited form as:

Cancer. 2018 January 15; 124(2): 391–397. doi:10.1002/cncr.31022.

The Cost and Cost-Effectiveness of Childhood Cancer Treatment in El Salvador, Central America: A Report from the Childhood Cancer 2030 Network

Soad Fuentes-Alabi, MD, MPH[1], **Nickhill Bhakta, MD, MPH**[2], **Roberto Franklin Vasquez, MD**[1], **Sumit Gupta, MD, PhD, FRCPC**[3], and **Susan Horton, BA, MA, PhD**[4]

[1]Department of Oncology, Benjamin Bloom Hospital, San Salvador, El Salvador

[2]Department of Global Pediatric Medicine, St. Jude Children's Research Hospital, Memphis, Tennessee, USA

[3]Division of Hematology/Oncology, Hospital for Sick Children, Toronto, Ontario, Canada, and Child Health Evaluative Sciences, Hospital for Sick Children, Toronto, Ontario, Canada

[4]Professor and CIGI Chair in Global Health Economics, School of Public Health and Health Systems, University of Waterloo, Ontario, Canada

Abstract

Background—Although previous studies have examined the cost of treating individual childhood cancers in low- and middle-income countries, none have examined the overall cost and cost-effectiveness of operating a childhood cancer treatment centre. We examine the cost and sources of financing of a pediatric cancer unit in Hospital Nacional de Niños Benjamin Bloom in El Salvador, and make estimates of cost-effectiveness.

Methods—Administrative data on costs and volumes of inputs were obtained for 2016 for the pediatric cancer unit. Similar cost and volume data were obtained for shared medical services provided centrally (e.g. blood bank). Costs of central non-medical support services (e.g. utilities) were obtained from hospital data and attributed by inpatient share. Administrative data were also used for sources of financing. Cost-effectiveness was estimated based on number of new patients diagnosed annually and survival rates.

Results—The pediatric cancer unit cost $5.2 million to operate in 2016, seeing 90 outpatients/day and 1,385 inpatient stays/year. Three-quarters (74.7%) of costs were attributed to four items: personnel (21.6%), pathological diagnosis (11.5%), pharmacy (chemotherapy, supportive care medications, and nutrition – 31.8%), and blood products (9.8%). Funding sources included government (52.5%), charitable foundations (44.2%), and a social security contribution scheme (3.4%). Based on 181 new patients/year and a five-year survival of 48.5% the cost per

Corresponding Author: Susan Horton, School of Public Health and Health Systems, University of Waterloo, 200 University Avenue West, Waterloo ON N2L 3G1, Canada. sehorton@uwaterloo.ca. Tel 1-519-888-4567 x37730.

Conflict of Interest: The authors have no conflict of interest to disclose.

Discipline: pediatric oncology

Authors' Contribution: Conceptualization, NB, SG, SH; Data Curation, SFA, RFV; Formal Analysis/software, SFA, RFV, SH, NB; Writing original draft, NB, SFA, SH, SG, Review and editing the final manuscript, NB, SFA, RFV, SG, SH

Disability Adjusted Life Year averted was $1624, under the threshold considered very cost-effective.

Conclusions—Treating childhood cancer in a specialized unit in a lower-middle income country can be done cost-effectively. Strong support from charitable foundations aids with affordability.

Keywords

cancer; cost effectiveness; economic evaluation; oncologic services; pediatric hospitals

BACKGROUND

For children diagnosed with cancer who live in high-income countries (HICs) with access to modern therapy, survival rates are now above 80%.[1] In low- and middle-income countries (LMICs), however, where 90% of the pediatric population lives, survival estimates vary between 10–50%.[2] A major factor limiting efforts to improve childhood cancer survival in LMICs remains the perception that pediatric oncology services are “too expensive” for LMIC health systems to absorb. Despite this assumption, the financial and economic costs required to treat pediatric cancer in LMICs remain largely unknown.

Several publications have described limited aspects of this costing narrative in LMICs by focusing on specific cancer treatments, protocols, or procedures.[3–5] Others have compared the cost-effectiveness of different treatment components for specific cancers.[6,7] The methods used have varied substantially in terms of rigor, estimation approaches and from whose perspective the costs were calculated.

Most importantly, to our knowledge, no data describing the global costs of running a childhood cancer service in a LMIC have been published. This represents a major gap with negative downstream implications for national cancer control planning and hospital-based implementation. This paucity of data is particularly concerning given a recent cost-effectiveness analysis suggesting that curing several types of childhood cancers may even be very cost-effective in low-income countries. In anticipation of an upcoming commission in *The Lancet Oncology* focused on Sustainable Pediatric Cancer Care, we have developed and applied a transparent method to estimate both the total cost and cost-effectiveness of maintaining the only comprehensive pediatric cancer treatment program in El Salvador.

METHODS

This study uses hospital administrative data for 2016 to report the costs of running and maintaining a pediatric cancer unit in Hospital Nacional de Niños Benjamin Bloom (HNNBB), a public referral and teaching hospital for children in San Salvador, El Salvador, using the hospital’s perspective. Costs were compared with the average five-year survival rate for all presenting cases 2012–2016 across all types of pediatric cancers treated. Since this study used de-identified and aggregated administrative data, the requirement for institutional review board approval was waived.

Study site

HNNBB is a 300-bed tertiary referral hospital with 1,350 employees and 300,000 patient visits annually.[8] The oncology department is one of 30 departmental subspecialties. The department diagnoses an average of 180 new patients per year, has 24 inpatient beds, and includes an outpatient clinic that sees over 30,000 patient visits annually. Some services and staff are dedicated to the unit, while other specialized services including surgery, pathology, imaging, pharmacy, radiation, and blood bank, as well as non-medical central services including utilities and purchasing and contracting services, are shared across the hospital. The HNNBB department is the main treatment centre for childhood cancer in El Salvador with treatment programs focusing on leukemias, lymphomas, and solid tumours such as Wilms tumor and sarcomas. The department treats children up to 14 years old, with an average age at diagnosis of six years.

The pediatric oncology program is financially sustained primarily by the Ministry of Health and the private non-profit foundation ‘Ayudame a Vivir’. Other partners or collaborators include: ASAPAC (Association of Parents of Children with Cancer), ISSS (El Salvador’s Institute of Social Security), and St. Jude Children’s Research Hospital. The ASAPAC plays an important role in the day-to-day operation of the pediatric oncology program, including fundraising and providing financial assistance to very low-income families for transportation, meals, laboratory tests and some medications not funded by the national health care system.

Data collection

Since the Department of Oncology is a separate administrative unit within HNNBB, we were able to obtain aggregated information on the hospital costs associated with diagnosing and treating childhood cancer. To collect costing data, a detailed abstraction tool was developed after compartmentalizing costs into the following categories: personnel (both medical and support), other services (IT, training), room and board for patients and for their families (“hotelling”), outpatient clinic, shared services (pharmacy, pathology, surgery, radiation, imaging, and blood bank), and other central hospital services (utilities, human resources, etc.). The structure of the abstraction tool is available in the Supplemental Appendix. The personnel cost of running a population-based cancer registry and outcome-tracking tool was also included in the total for personnel, given the importance of such efforts.[9,10]

Information for the volume and unit cost of items came from various sources. The pediatric oncology unit has its own information system with data on the number of personnel dedicated to the department and their salaries, services specific to the unit (lab information system, training, space for the outpatient clinic) as well as costs and quantity of some of the shared hospital services used by the department (pharmacy, pathology, and blood services). In other cases of shared services (surgery, imaging, and radiation therapy) key personnel were consulted as to the proportion of their time/workload attributable to pediatric oncology; costs were prorated. Overhead costs from central administration were obtained from the budget of the hospital overall and covered the cost of essential central functions such as

utilities, and purchasing and contracting services. These were attributed according to the pediatric oncology unit share of total inpatient admissions (11.2%).

For inpatient "hotelling" costs, we used the WHO-CHOICE[11] value for El Salvador for 2008, updated to 2016 using the US Consumer Price Index.[12] For Intensive Care Unit (ICU) beds we multiplied this value by 3.5, the ratio of the cost per day for ICU compared to that of a regular hospital bed in the El Salvador government fee structure.

The number of inpatients and outpatients per year, number of new childhood cancer cases per year, and estimated survival rates were taken from the Morbi-Mortality Information System (SIMMOW)[13] which is based on the population-based Pediatric Cancer Registry maintained by HNNBB. In order to make cost-effectiveness estimates, we assumed that all children diagnosed with cancer would die if left untreated. Five-year survival rates were obtained from the Registry, using data from new cases for 2012–16. We compared the costs of treatment in 2016 with five-year survival data to 2016, thereby using a prevalence rather than incidence-based calculation.

Cost-effectiveness analysis

Cost-effectiveness was calculated using the disability adjusted life years (DALYs) approach used by the Global Burden of Disease[14] Study (GBD). Full details and citations of model variables used are provided in Table 1. Full model calculations of years of life lost and years lived with disability were adapted from previously published models[15] and are available for review in the Supplemental Appendix. As average length of therapy varies based on the type of cancer, we used an assumed average of 2-years "on therapy" in order to calculate years lived with disability.

We also varied three parameters in sensitivity analyses: discount rate, extent of excess long-term morbidity, and years of life lost as a result of earlier mortality due to late effects associated with cancer. First, a discount rate of 3% was used for the base case, with alternate values of 0% and 6%. Second, to address the observed excess morbidity associated with surviving childhood cancer,[16] we used published utility scores from the Medical Expenditure Panel Survey (MEPS),[17] a sample representative of the United States general population, and the Childhood Cancer Survivorship Study (CCSS), a prospective cohort survey of 5-year cancer survivors in the United States and Canada, to derive proxy disability weights. This approach was selected as the GBD does not account for cancer-related late-effects and no disability weight for survivorship exists within the GBD framework.[18] To derive a disability weight to account for excess morbidity associated with childhood cancer treatment, the proportional difference between MEPS and CCSS utility scores at any given age was used. MEPS and CCSS data are only available at three age-points, so one-way interpolation was applied to obtain weights at different ages within the range of known data points. Finally, to account for early mortality, we varied a possible reduction in life expectancy from 0% to 30%, a range that incorporates estimates of early mortality from the United States.[19,20] In total, 15 scenarios were thus modelled (sensitivity analysis).

Final cost-effectiveness analyses were calculated for each scenario in both the base case and the sensitivity analyses. Per WHO-CHOICE criteria,[11] an intervention is considered to be

"cost-effective" if the cost to avert 1 DALY is between 1 to 3 times a country's per capita gross domestic product (GDP). The intervention is considered to be "very cost effective" if the cost is less than 1 times GDP per capita. Interventions costing more than three times per capita GDP per DALY averted are not considered cost-effective.

RESULTS

A total of 907 new cases of childhood cancer were treated at HNNBB between 2012–2016. This cohort included 434 (47.9%) cases of leukemia, 355 (39.1%) of which were acute lymphoblastic leukemia. The remained included cases of lymphoma (94, 10.4%), central nervous system tumors (88, 9.7%) and various extracranial solid tumors (291, 32.1%). The five-year overall survival for the entire cohort was 48.5% +/− 5.6%. Of the entire cohort, only one patient abandoned therapy.

Table 2 summarizes the total cost and its major components. Supporting details (unit costs and quantities) are shown in Supplemental Table 1. Personnel and shared hospital medical services accounted for 88.8% of costs. The largest individual costs were personnel (24.0%), pathologic diagnosis (12.9%), pharmacy (including chemotherapy, supportive care medications, and nutrition - 35.5%), and blood services (11.0%). All other categories (radiation, imaging, surgery, hotelling, utilities, and "other") accounted for less than 11% combined. The annual cost totalled $5.2m, i.e. $28,707 per year per newly diagnosed child.

Financing of care for pediatric oncology costs came primarily from two major sources: the government, and HNNBB's non-profit foundation "Ayúdame a Vivir". "Ayúdame a Vivir" covered the salary of 30 medical personnel (20 of the 40 nurses, two pediatricians, four oncologists, three laboratory technicians, and a portion of one surgeon). The same foundation also covered all costs related to diagnostic pathology, chemotherapy, supportive care medications, and anaesthesia associated with radiation treatment. The government contributory social security scheme ISSS covered the cost of the time needed in radiation therapy and the salary of four radiation oncologists. The parents' foundation ASAPAC covered the cost of room and board for families accompanying their children, while St. Jude's provided technical support as well as some financial support of Ayudame a Vivir. The government covered all other costs within the pediatric oncology unit. In total, just over half of associated costs of treatment were financed by the government (52.5%), with the rest provided by Ayúdame a Vivir (42.9%), other foundations (1.3%), and the social security contributory scheme (3.4%). This calculation excludes the $616,000 in costs of central hospital administration and utilities.

The parameters used to determine the cost-effectiveness of treating childhood cancer in El Salvador are detailed in Table 1. The results of the analysis are summarized in Table 3. The cost to avert 1 DALY in the base case model (no early mortality or excess morbidity; 3% discounting) was $1624 as compared to El Salvador's per capita GDP of $4219 in 2015 (GDP data for 2016 were not yet available). This is very cost-effective as per WHO-CHOICE criteria. In two-way sensitivity analyses that allowed for variation in the discount rate weights, possible excess morbidity late effects as a result of childhood cancer therapy,

and possible early mortality as a result of childhood cancer therapy, the resultant costs always remained very cost-effective (i.e. below the one times GDP per capita threshold).

DISCUSSION

This is the first published study describing the costs, financing, and cost-effectiveness of a comprehensive childhood cancer treatment centre in a LMIC. Previous work in this area has calculated costs for specific childhood cancer treatment protocols, often not taking account of patients who do not complete treatment, and has not presented cost-effectiveness estimates.[3–5] Our analysis suggests that treating selected childhood cancers in the context of a high-functioning centre is a very cost-effective opportunity in a LMIC. In this study, we have developed a reporting tool to assist health centers when calculating the complete costs necessary to treat childhood cancer. Additionally, after applying this tool at HNNBB in El Salvador and combining our cost-estimates with the survival data available, we show that even when late effects and early mortality are incorporated, childhood cancer treatment strategies in El Salvador are very-cost effective as per the WHO-CHOICE definitions used to prioritize health interventions.

We found that the cost per year per newly diagnosed case was $28,707 This per-patient cost is generally higher than treatment costs reported in studies for individual cancers for LMICs.[3–5] Studies of individual cancers often do not include costs for those abandoning therapy or succumbing to treatment-related toxicity. Global costs associated with running a childhood cancer unit are also rarely included. The figures provided in this study are therefore more comprehensive and reliable.

At the same time, these results highlight the issue of affordability as distinct from cost-effectiveness. The cost per year per newly diagnosed case of $28,707 compares to a per capita health expenditure in El Salvador in 2014 of only $280 (data for 2016 were not yet available).[21] How childhood cancer treatment can be successfully financed in LMICs is therefore of significant importance.

In the case of HNNBB, the hospital has been successful in maintaining a strong program with the assistance of private foundations that provided 44.2% of the funding for pediatric oncology (not counting the central hospital administration costs). The hospital foundation ‘Ayudame a Vivir’ funded all chemotherapy and supportive care as well as key personnel (half the complement of nurses, all the oncologists and both pediatricians). ‘Ayudame a Vivir’ has supported the unit for over 25 years, and is currently funded predominantly (approximately 94%) through Salvadoran philanthropy and revenue streams. Strong support from charitable foundations has also been described as a key component of successful childhood cancer treatment centers in other countries.[22,23] Such support may include financing of core and ancillary costs, educational campaigns, family support groups, and advocacy targeting governments and other stakeholders. Without the support of ‘Ayudame a Vivir’ and other foundations, the ability of HNNBB to achieve the cancer outcomes described in this study would likely be severely impacted.

Charitable support also allowed the unit to hire psychologists and social workers who have been key to reducing treatment abandonment (Salverria et al, 2015).[24] Abandonment of treatment, a complex phenomenon with multiple contributing factors, represents a common cause of treatment failure in many LMIC settings.[25–27] The parental foundation ASAPAC was also instrumental in decreasing local abandonment rates by funding accommodation, per diems, and where necessary, medication for parents with limited incomes. Future costing studies in LMIC childhood cancer must therefore include costs associated with psychosocial and family support, as they are integral determinants of survival outcomes.

Limitations of the costing component of this study included the inability to fully cost all inputs. For example, we did not have a cost estimate associated with the rental of space for inpatients. We assumed that the hospital rates charged for services like operating theatres, pathology, and radiation included the amortization costs of equipment. We did not have financial records to allocate the shared services of surgery, imaging, and radiation therapy, and relied instead on self-reporting by key personnel concerned. However these three components combined account for less than 5% of the overall treatment cost; thus any resultant recall bias or misclassification is likely modest in size. Since we only examined costs incurred at a children's hospital, costs associated with the treatment of late effects for cancer survivors after the age of fourteen (when they would be treated at an adult hospital) were not included. We also did not include indirect costs borne by the families (loss of work time caring for their child, travelling to get treatment, additional costs of medication etc) and instead restricted our analyses to the perspective of the hospital. Other studies for LMICs have shown that indirect costs can often be considerable for the family and can lead to treatment abandonment.[28] Despite these limitations, this study represents the most comprehensive costing of LMIC childhood cancer treatment to date.

Limitations of the cost-effectiveness analysis are mainly a reflection of the lack of LMIC-specific late-effect data in the published literature. The GBD does not account for late-effects of cancer (childhood or adult) in their DALY estimation methods. We instead used utility estimates for childhood cancer survivors[29] in an American population that may not reflect cultural variations in health related quality of life. Additionally, although early mortality[19,30] for childhood cancer survivors is well described in high-income countries, whether these data are generalizable to LMICs is uncertain. There are currently no LMIC survivorship cohort studies with which to anchor our sensitivity analysis. Weaker health systems in LMIC would suggest that patients who develop early morbidity would die even earlier due to the lack of appropriate care, potentially making our results overly optimistic. On the other hand, LMIC treatment protocols are often of lower intensity than those used in high-income countries due to less robust supportive care options (i.e., infection control, intensive care, stem cell therapy). Late effects in LMIC survivors may thus be less severe compared to HIC cohorts. It is important to note that sensitivity analyses increasing the theoretical burden of cancer survivorship in our study did not change the cost-effectiveness of treatment. Finally, the generalizability of our results to other LMIC settings and other models of childhood cancer care delivery are unknown. Efforts to duplicate these analyses in other LMIC jurisdictions are currently underway.

In conclusion, we have provided a framework for reporting the costs of maintaining a comprehensive childhood cancer treatment center in one LMIC and have shown that investments in this program are very cost-effective. Our results need to be duplicated in other LMICs, preferably of different income levels. The included tools developed for this study may be useful in such duplications. Patient advocates and policymakers can use our results to inform national childhood cancer strategies that aim to improve LMIC childhood cancer outcomes. Additional future work will identify costs for treating specific childhood cancer subgroups in order to help prioritize allocation of resources.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding source: Soad Fuentes-Alabi acknowledges funding support from St. Baldrick's Foundation.

Grant: P30 CA021765.

The authors would like to thank all of the cooperating pediatric oncology employees and administrative personnel from HNBB for providing the cost information. The authors would also like to thank Carlos Rodriguez-Galindo, Chair, Department of Global Pediatric Medicine at St. Jude Children's Research Hospital; Lindsay Frazier, Department of Pediatrics, Harvard Medical School and Rifat Atun, Professor of Global Health Systems, Harvard University. Together with Sumit Gupta, they are the co-chairs of the ongoing Lancet Commission on Pediatric Oncology. Their support and encouragement led to this study. The support of St. Baldrick's Foundation and the American Lebanese Syrian Associated Charities (ALSAC) is also gratefully acknowledged.

References

1. Smith MA, Seibel NL, Altekruse SF, et al. Outcomes for children and adolescents with cancer: challenges for the twenty-first century. Journal of clinical oncology: official journal of the American Society of Clinical Oncology. 2010; 28(15):2625–2634. [PubMed: 20404250]
2. Rodriguez-Galindo C, Friedrich P, Alcasabas P, et al. Toward the Cure of All Children With Cancer Through Collaborative Efforts: Pediatric Oncology As a Global Challenge. Journal of clinical oncology: official journal of the American Society of Clinical Oncology. 2015; 33(27):3065–3073. [PubMed: 26304881]
3. Ji X, Xuan Y, Li J, et al. Direct costs for retinoblastoma treatment during the first year of comprehensive therapy in China. Journal of pediatric ophthalmology and strabismus. 2012; 49(6): 353–358. [PubMed: 22800796]
4. Luo XQ, Ke ZY, Guan XQ, Zhang YC, Huang LB, Zhu J. The comparison of outcome and cost of three protocols for childhood non-high risk acute lymphoblastic leukemia in China. Pediatric blood & cancer. 2008; 51(2):204–209. [PubMed: 18454471]
5. Stefan DC, Stones D. How much does it cost to treat children with Hodgkin lymphoma in Africa? Leukemia & lymphoma. 2009; 50(2):196–199. [PubMed: 19197725]
6. García M, Chicaíza LA, Quitián H, Linares A, Ramírez Ó. Costo-efectividad de los tratamientos de consolidación para la leucemia mieloide aguda en niños en riesgo alto en el sistema de salud colombiano. Biomédica. 2015; 35(4):549–556. [PubMed: 26844444]
7. García-Molina M, Chicaíza-Becerra L, Moreno-Calderon A, Prieto-Martínez V, Sarmiento-Urbina I, Linares-Ballesteros A. Costo-efectividad de 18FDG-PET/CT vs CT al final del tratamiento en pacientes pediátricos con Linfoma Hodgkin. Revista de Salud Pública. 2014; 16:260–269. [PubMed: 25383499]
8. Hospital BB. [Accessed 07 February, 2017] Hospital Services [online]. 2017. http://www.hospitalbloom.gov.sv/principal/historia.html

9. Tangka FK, Subramanian S, Edwards P, et al. Resource requirements for cancer registration in areas with limited resources: Analysis of cost data from four low- and middle-income countries. Cancer epidemiology. 2016; 45(Suppl 1):S50–s58. [PubMed: 27793574]
10. Jha P, Chaloupka FJ, Moore J, et al. Disease control priorities in developing countries. Disease control priorities in developing countries. 2006
11. (WHO) WHO. Health Service Delivery Costs. [Accessed 21 April, 2017] WHO-CHOICE unit cost estimates for service delivery. 2017. Available at: http://www.who.int/choice/cost-effectiveness/inputs/health_service/en/
12. Labor USDo. Bureau of Labor Statistics. [Accessed 04 May, 2017] CPI (all urban consumers) Current Series. 2017. Available at: https://data.bls.gov/cgi-bin/surveymost
13. Salvador MdSE. [Accessed 07 May, 2017] MorbiMortalidad Estradisticas Vitales (SIMMOW). 2017. http://simmow.salud.gob.sv/
14. Murray CJ, Lopez AD. Organization WH. The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020: summary. 1996
15. Bhakta N, Martiniuk AL, Gupta S, Howard SC. The cost effectiveness of treating paediatric cancer in low-income and middle-income countries: a case-study approach using acute lymphocytic leukaemia in Brazil and Burkitt lymphoma in Malawi. Archives of disease in childhood. 2013; 98(2):155–160. [PubMed: 23201550]
16. Oeffinger KC, Mertens AC, Sklar CA, et al. Chronic health conditions in adult survivors of childhood cancer. The New England journal of medicine. 2006; 355(15):1572–1582. [PubMed: 17035650]
17. Quality USDoHaHS-AAfhRa. [Accessed 07 May, 2017] Medical Expenditure Panel Survey. 2017. https://meps.ahrq.gov/mepsweb/
18. Fitzmaurice C, Allen C, Barber RM, et al. Global, Regional, and National Cancer Incidence, Mortality, Years of Life Lost, Years Lived With Disability, and Disability-Adjusted Life-years for 32 Cancer Groups, 1990 to 2015: A Systematic Analysis for the Global Burden of Disease Study. JAMA oncology. 2017; 3(4):524–548. [PubMed: 27918777]
19. Armstrong GT, Yasui Y, Robison LL. Reduction in Late Mortality after Childhood Cancer. The New England journal of medicine. 2016; 375(3):290–292. [PubMed: 27468077]
20. Yeh JM, Nekhlyudov L, Goldie SJ, Mertens AC, Diller L. A model-based estimate of cumulative excess mortality in survivors of childhood cancer. Annals of internal medicine. 2010; 152(7):409–417. w131–408. [PubMed: 20368646]
21. Bank TW. [Accessed 21 April, 2017] World Bank Open Data. 2017. http://data.worldbank.org/
22. Antillon F, Baez FL, Barr R, et al. AMOR: a proposed cooperative effort to improve outcomes of childhood cancer in Central America. Pediatric blood & cancer. 2005; 45(2):107–110. [PubMed: 15806545]
23. Ribeiro RC, Antillon F, Pedrosa F, Pui CH. Global Pediatric Oncology: Lessons From Partnerships Between High-Income Countries and Low- to Mid-Income Countries. Journal of clinical oncology: official journal of the American Society of Clinical Oncology. 2016; 34(1):53–61. [PubMed: 26578620]
24. Salaverria C, Rossell N, Hernandez A, et al. Interventions targeting absences increase adherence and reduce abandonment of childhood cancer treatment in El Salvador. Pediatric blood & cancer. 2015; 62(9):1609–1615. [PubMed: 25925227]
25. Bonilla M, Rossell N, Salaverria C, et al. Prevalence and predictors of abandonment of therapy among children with cancer in El Salvador. International journal of cancer. 2009; 125(9):2144–2146. [PubMed: 19585496]
26. Gupta S, Yeh S, Martiniuk A, et al. The magnitude and predictors of abandonment of therapy in paediatric acute leukaemia in middle-income countries: a systematic review and meta-analysis. European journal of cancer (Oxford, England: 1990). 2013; 49(11):2555–2564.
27. Weaver MS, Howard SC, Lam CG. Defining and distinguishing treatment abandonment in patients with cancer. Journal of pediatric hematology/oncology. 2015; 37(4):252–256. [PubMed: 25757024]

28. Arora RS, Eden T, Pizer B. The problem of treatment abandonment in children from developing countries with cancer. Pediatric blood & cancer. 2007; 49(7):941–946. [PubMed: 17252565]

29. Yeh JM, Hanmer J, Ward ZJ, et al. Chronic Conditions and Utility-Based Health-Related Quality of Life in Adult Childhood Cancer Survivors. Journal of the National Cancer Institute. 2016; 108(9)

30. Armstrong GT, Liu Q, Yasui Y, et al. Late mortality among 5-year survivors of childhood cancer: a summary from the Childhood Cancer Survivor Study. Journal of Clinical Oncology. 2009; 27(14): 2328–2338. [PubMed: 19332714]

Table 1

Variables and Sources included in the Cost-Effectiveness Model

Variables	Values	*Sources*
Discount rate	0.03 (0, 0.06)	*WHO-CHOICE*
El Salvador life expectancy 2015 (latest available)	73	*World Bank*
Mean age at diagnosis	6	*HNNBB Provided Data*
Duration of disability (length of therapy)	2	*Assumed length of therapy*
Disability weight during therapy	0.288	*GBD 2016*
Utility Score at age 24 using MEPS *	0.826	*Yeh et al, 2016*
Utility Score at age 35 using MEPS *	0.81	*Yeh et al, 2016*
Utility Score at age 24 using CCSS Survivors **	0.779	*Yeh et al, 2016*
Utility Score at age 35 using CCSS Survivors **	0.766	*Yeh et al, 2016*
Number of new incident cases	181	*HNNBB Provided Data*
Proportion of patients with 5-year overall survival	0.49	*HNNBB Provided Data*
El Salvador GDP per capita 2015 (latest available)	4219	*World Bank*

* MEPS refers to the Medical Expenditures Panel Survey and provides utility weights generalizable to the United States general population.[17]

** CCSS refers to the Childhood Cancer Survivorship Study and provides utility weights for late effects for those who received treatment for cancer in childhood[16]

Table 2

Annual costs of operating pediatric oncology department by major cost category

Input	Quantity	Annual Cost (US $ '000)	% of total cost
Personnel			
- Medical[a]	65 FTE	840.6	
- Non-medical[b]	20 FTE	280.6	
Subtotal - personnel		**1121.2**	**21.6**
Hotelling			
– general ward[c]	3.63/day (average)	61.9	
- ICU	0.92/day (average)	57.3	
- local housing and per diem for families	5 families/day	116.9	
Subtotal- hotelling		**236.1**	**4.5**
Subtotal – outpatient clinic[d]		**135.1**	**2.6**
Subtotal – other services (training, lab info)		**69.4**	**1.3**
Shared hospital medical services			
- pathology		600.0	
- pharmacy		1654.8	
- radiation		51.9	
- imaging		71.2	
- surgery (operating theatre)		130.0	
- blood services		510.6	
Subtotal – shared hospital medical services		**3018.5**	**58.1**
Subtotal – utilities[e]		**78.3**	**1.5**
Subtotal: central administration cost[e]		**537.6**	10.3
TOTAL		**5195.8**	**100.0**

Notes:

[a]Includes oncologists (4 FTE), pediatricians (3FTE), radiation oncologists (4FTE), pharmacists (4FTE), Nurses (40 FTE), general surgeon (1FTE), orthopedic surgeon (1FTE), neurosurgeons (4FTE), pathologists (2 FTE), lab technicians (2FTE), pain specialist (1 FTE)

[b]Includes Departmental Registrar (1FTE), Cancer Registrar (1 FTE), oncological psychiatrists (2 FTE), social workers (2 FTE), ambulance driver (1 FTE), secretarial support (3 FTE), managers (3 FTE), warehouse personnel (2 FTE) accountant (1 FTE), data entry (3 FTE)

[c]Includes cost of cleaning, maintenance, laundry, food for patients, etc. Costs of cooks (3 FTE), maintenance personnel (7 FTE) and security personnel (2FTE) are incorporated here.

[d]Includes space cost for outpatient clinic: treatment costs for outpatients is included under various treatment headings

[e]Includes unit's share of central utilities and purchasing and contracting administration costs, weighted by cancer unit share of HNNBB total inpatient stays (11.2%)

Table 3

Cost per DALY averted, base case and sensitivity analysis

Scenarios of Life Expectancy (LE)* and Late Effect Morbidity	Discounting		
	0%	3%	6%
Base Case (Normal LE, No Utility Adjustment for Late Effect Morbidity)	$ 878	$ 1,624	$ 2,857
Normal LE + Utility Adjustment for Late Effect Morbidity	$ 936	$ 1,643	$ 2,866
10% Reduction in LE + Utility Adjustment for Late Effect Morbidity	$ 1038	$ 1,681	$ 2,885
20% Reduction in LE + Utility Adjustment for Late Effect Morbidity	$ 1,186	$ 1,747	$ 2,923
30% Reduction in LE + Utility Adjustment for Late Effect Morbidity	$ 1,382	$ 1,851	$ 2,995

*Decrements in Life Expectancy[29,30]