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

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**Background.** Although previous studies have examined the cost of treating individual childhood cancers in low-income and middle-income countries, to the authors' knowledge none has examined the overall cost and cost-effectiveness of operating a childhood cancer treatment center. Herein, the authors examined the cost and sources of financing of a pediatric cancer unit in Hospital Nacional de Ninos Benjamin Bloom in El Salvador, and make estimates of cost-effectiveness.

**Methods.** Administrative data regarding 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 (eg, blood bank). Costs of central nonmedical support services (eg, utilities) were obtained from hospital data and attributed by inpatient share. Administrative data also were used for sources of financing. Costeffectiveness was estimated based on the number of new patients diagnosed annually and survival rates.

**Results.** The pediatric cancer unit cost $5.2 million to operate in 2016 (treating 90 outpatients per day and experiencing 1385 inpatient stays per year). Approximately three-quarters of the cost (74.7%) was attributed to 4 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 per year and a 5-year survival rate of 48.5%, the cost per disability-adjusted life-year averted was $1624, which is under the threshold considered to be very cost effective.

**Conclusions.** Treating childhood cancer in a specialized unit in low-income and middleincome countries can be done cost-effectively. Strong support from charitable foundations aids with affordability. Cancer 2018; 124:391-7. © 2017 American Cancer Society.

**Keywords:** cancer, cost-effectiveness, economic evaluation, oncologic services, pediatric hospitals.

## Introduction

For children diagnosed with cancer who live in high-income countries with access to modern therapy, survival rates currently are >80%.[1] However, in low-income and middle-income countries (LMICs), where approximately 90% of the pediatric population lives, survival estimates vary between 10% and 50%.[2] A major factor limi-

ting 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, to our knowledge 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 important, to our knowledge, no data describing the global costs of running a childhood cancer service in an LMIC have been published to date. 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 costeffective 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 with which to estimate both the total cost and cost-effectiveness of maintaining what to our knowledge is the only comprehensive pediatric cancer treatment program in El Salvador.

## Materials and methods

The current study used hospital administrative data for 2016 to report the costs of running and maintaining a pediatric cancer unit in Hospital Nacional de Ninos 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 5-year survival rate for all presenting cases for 2012 through 2016 across all types of pediatric cancers treated. Because this study

used deidentified and aggregated administrative data, the requirement for institutional review board approval was waived.

## Study Site

HNNBB is a 300-bed tertiary referral hospital with 1350 employees and 300,000 patient visits annually.[8] The oncology department is 1 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 has >30,000 patient visits annually. Some services and staff are dedicated to the unit, whereas other specialized services, including surgery, pathology, imaging, pharmacy, radiation, and blood bank, as well as nonmedical central services, including utilities and purchasing and contracting services, are shared across the hospital. The HNNBB department is the main treatment center for childhood cancer in El Salvador, with treatment programs focusing on leukemias, lymphomas, and solid tumors such as Wilms tumor and sarcomas. The department treats children aged ≤ 14 years, with an average age at the time of diagnosis of 6 years.

The pediatric oncology program is financially sustained primarily by the Ministry of Health and the private nonprofit foundation "Ayudame a Vivir." Other partners or collaborators include the Association of Parents of Children with Cancer (ASAPAC), El Salvador's Institute of Social Security, and St. Jude Children's Research Hospital. The ASAPAC plays an important role in the day-today 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

Because the department of oncology is a separate administrative unit within HNNBB, we were able to obtain aggregated informa-

tion regarding 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 (information technology, training), room and board for patients and for their families ("hoteling"), 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 Supporting Information Table 1. The personnel cost of running a population-based cancer registry and outcometracking tool also was included in the total for personnel, given the importance of such efforts.[9,10]

Information regarding the volume and unit cost of items came from various sources. The pediatric oncology unit has its own information system with data regarding the number of personnel dedicated to the department and their salaries and services specific to the unit (laboratory information system, training, and 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 radiotherapy), key personnel were consulted regarding the percentage 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 "hoteling" costs, we used the World Health Organization (WHO)-CHOICE[11] value for El Salvador for 2008, updated to 2016 using the US consumer price index.[12] For intensive care unit beds, we multiplied this value by 3.5, the ratio of the cost per day for the intensive care unit compared with that of a regular hospital bed in the El Salvador government fee structure.

**Table 1.** *Variables and Sources Included in the Cost-Effectiveness Model*

| Variables | Values | Values |
|---|---|---|
| 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 201614 |
| Utility score at age 24 y using MEPS[a] | 0.826 | Yeh 201615 |
| Utility score at age 35 y using MEPS[a] | 0.81 | Yeh 201615 |
| Utility score at age 24 y using CCSS survivors[b] | 0.779 | Yeh 201615 |
| Utility score at age 35 y using CCSS survivors[b] | 0.766 | Yeh 201615 |
| No. of new incident cases | 181 | HNNBB-provided data |
| Proportion of patients with 5-y overall survival | 0.49 | HNNBB-provided data |
| El Salvador GDP per capita 2015 (latest available) | 4219 | World Bank |

*Abbreviations:* CCSS, Childhood Cancer Survivor Study; GBD, Global Burden of Disease; GDP, gross domestic product; HNNBB, Hospital Nacional de Ninos Benjamin Bloom; MEPS, Medical Expenditures Panel Survey; WHO, World Health Organization.

[a] MEPS provides utility weights generalizable to the US general population.[16]

[b]*CCSS* provides utility weights for late effects for those who received treatment for cancer in childhood.[17]

The number of inpatients and outpatients per year, the number of new childhood cancer cases per year, and estimated survival rates were taken from the Morbi- Mortality Information System of the Ministry of Health of El Salvador (SIMMOW),[13] which is based on the population-based pediatric cancer registry maintained by HNNBB. 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 through 2016. We compared the costs of treatment in 2016 with 5-year survival data to 2016, thereby using a prevalence rather than incidence-based calculation.

## Cost-Effectiveness Analysis

Cost-effectiveness was calculated using the disabilityadjusted life-years (DALYs) approach used by the Global Burden of Disease (GBD)[14] study. Full details and citations of model variables used are provided in Table 1.[15-17] Full model calculations of years of life lost and years lived with disability were adapted from previously published models,[18] and are available for review in Supporting Information Table 1. Because the average length of therapy varies based on the type of cancer, we used an assumed average of 2 years "on therapy" to calculate years lived with disability.

We also varied 3 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,[17] we used published utility scores from the Medical Expenditure Panel Survey (MEPS),[16] a sample representative of the US general population, and the Childhood Cancer Survivor 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 because the GBD does not account for cancerrelated late effects and no disability weight for survivorship exists within the GBD framework.[19] To derive a disability weight to account for the 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 3 age points, and therefore 1-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.[20,21] In total, 15 scenarios thus were modeled (sensitivity analysis).

Final cost-effectiveness analyses were calculated for each scenario in both the base case and the sensitivity analyses. As 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 gross domestic product (GDP) per capita. The intervention is considered to be "very cost effective" if the cost is <1 times the GDP per capita. Interventions costing >3 times the GDP per capita per DALY averted are not considered to be costeffective.

**Table 2.** *Annual Costs of Operating a Pediatric Oncology Department by Major Cost Category*

| Input | Quantity | Annual Cost, US$ | Percentage of Total Cost |
|---|---|---|---|
| **Personnel** | | | |
| Medicala | 65 FTE | 840.6 | |
| Nonmedicalb | 20 FTE | 280.6 | |
| Subtotal: personnel | | 1121.2 | 21.6 |
| **Hoteling** | | | |
| General wardc | 3.63/d (average) | 61.9 | |
| ICU | 0.92/d (average) | 57.3 | |
| Local housing and per diem for families | 5 families/d | 116.9 | |
| Subtotal: hoteling | | 236.1 | 4.5 |
| Subtotal: outpatient clinicd | | 135.1 | 2.6 |
| Subtotal: other services (training, laboratory information) | | 69.4 | 1.3 |
| **Shared hospital medical services** | | | |
| Pathology | | 600.0 | |
| Pharmacy | | 1654.8 | |
| Radiation | | 51.9 | |
| Imaging | | 71.2 | |
| Surgery (operating room) | | 130.0 | |
| Blood services | | 510.6 | |
| Subtotal: shared hospital medical services | | 3018.5 | 58.1 |
| Subtotal: utilitiese | | 78.3 | 1.5 |
| Subtotal: central administration coste | | 537.6 | 10.3 |
| Total | | 5195.8 | 100.0 |

*Abbreviations:* FTE, full-time equivalent; ICU, intensive care unit.

[a] Includes oncologists (4 FTE), pediatricians (3 FTE), radiation oncologists (4 FTE), pharmacists (4 FTE), nurses (40 FTE), a general surgeon (1 FTE), an orthopedic surgeon (1 FTE), neurosurgeons (4 FTE), pathologists (2 FTE), laboratory technicians (2 FTE), and a pain specialist (1 FTE).

[b] Includes a departmental registrar (1 FTE), a cancer registrar (1 FTE), oncologi-

cal psychiatrists (2 FTE), social workers (2 FTE), an ambulance driver (1 FTE), secretarial support (3 FTE), managers (3 FTE), warehouse personnel (2 FTE), an accountant (1 FTE), and data entry personnel (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 (2 FTE) are incorporated here.

[d] Includes space cost for outpatient clinic; treatment costs for outpatients are included under various treatment headings.

[e] Includes the unit's share of central utilities andpurchasing and contracting administration costs, weighted by cancer unit share of Hospital Nacional de Ninos Benjamin Bloom total inpatient stays (11.2%).

## Results

A total of 907 new cases of childhood cancer were treated at HNNBB between 2012 and 2016. This cohort included 434 cases of leukemia (47.9%), 355 (39.1%) of which were acute lymphoblastic leukemia. The remaining cases included cases of lymphoma (94 cases; 10.4%), central nervous system tumors (88 cases; 9.7%), and various extracranial solid tumors (291 cases; 32.1%). The 5-year overall survival rate for the entire cohort was 48.5% ± 5.6%. Of the entire cohort, only 1 patient withdrew from therapy.

Table 2 summarizes the total cost and its major components. Supporting details (unit costs and quantities) are shown in Supporting Information Table 1. Personnel and shared hospital medical services accounted for approximately 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, hoteling, utilities, and "other") accounted for <11% combined. The annual cost totaled $5.2 million (ie, $28,707 per year per newly diagnosed child).

The financing of care for pediatric oncology costs came primarily from 2 major sources: the government and HNNBB's nonprofit

foundation Ayudame a Vivir. Ayudame a Vivir covered the salary of 30 medical personnel (20 of the 40 nurses, 2 pediatricians, 4 oncologists, 3 laboratory technicians, and a portion of the salary for 1 surgeon). The same foundation also covered all costs related to diagnostic pathology, chemotherapy, supportive care medications, and anesthesia associated with radiotherapy. The government contributory social security scheme, Institute of Social Security, covered the cost of the time needed for radiotherapy and the salary of 4 radiation oncologists. ASAPAC covered the cost of room and board for families accompanying their children. St. Jude's Children's Research Hospital provided significant funding to Ayudame a Vivir historically, and continues to provide about 10% of the funds raised annually by the foundation. St. Jude's also provides significant technical and educational assistance, both of which were felt by stakeholders to be critical to HNBBB's historical success. The government covered all other costs within the pediatric oncology unit. In total, just greater than one-half of the associated costs of treatment were financed by the government (52.5%), with the rest provided by Ayudame 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 costeffectiveness 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 compared with El Salvador's GDP per capita of $4219 in 2015 (GDP data for 2016 were not yet available). This is very cost effective as per WHO-CHOICE criteria. In 2-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 (ie, below the threshold of 1 times the GDP per capita).

**Table 3.** *Cost per DALY Averted, Base Case and Sensitivity Analysis*

| | Discounting | | |
|---|---|---|---|
| Scenarios of LEa and Late Effect Morbidity | 0% | 3% | 6% |
| Base case (normal LE, no utility adjustment for late effect morbidity) | $878 | $1624 | $2857 |
| Normal LE plus utility adjustment for late effect morbidity | $936 | $1643 | $2866 |
| 10% reduction in LE plus utility adjustment for late effect morbidity | $1038 | $1681 | $2885 |
| 20% reduction in LE plus utility adjustment for late effect morbidity | $1186 | $1747 | $2923 |
| 30% reduction in LE plus utility adjustment for late effect morbidity | $1382 | $1851 | $2995 |

*Abbreviations:* DALY, disability-adjusted life-year; LE, life expectancy.

*a* Decrements in LE.15,30

## Discussion

To the best of our knowledge, the current study is the first published study to date describing the costs, financing, and cost-effectiveness of a comprehensive childhood cancer treatment center in an LMIC. Previous work in this area has calculated the costs for specific childhood cancer treatment protocols, often not taking into account patients who do not complete treatment, and has not presented costeffectiveness estimates.[3-5] The current analysis suggests that treating selected childhood cancers within the context of a high-functioning center is a very cost-effective opportunity in an LMIC. In the current study, we developed a reporting tool to assist health centers when calculating the complete costs necessary to treat childhood cancer. In addition, after applying this tool at HNNBB in El Salvador and combining our cost estimates with the survival data available, the results herein demonstrated 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 generally is 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 patients who abandon therapy or who die of treatment-related toxicity. Global costs associated with running a childhood cancer unit also rarely are included. Therefore, the data provided in the current study are more comprehensive and reliable.

At the same time, these results highlight the issue of affordability as being distinct from cost-effectiveness. The cost per year per newly diagnosed case of $28,707 compares with a per-capita health expenditure in El Salvador in 2014 of only $280 (data for 2016 were not yet available). [22] Therefore, the question of how childhood cancer treatment can be successfully financed in LMICs is 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 (approximately one-half of the complement of nurses, all the oncologists, and both pediatricians). Ayudame a Vivir has supported the unit for >25 years, and is currently funded predominantly (approximately 94%) through Salvadoran philanthropy and revenue streams. Strong support from charitable foundations also has been described as a key component of successful childhood cancer treatment centers in other countries.[23, 24] Such support may include the financing of core and ancillary costs, educational campaigns, family support groups, and advocacy targeting governments and other stakeholders. Without the support of Ayudame a TABLE 3. Cost per DALY Averted, Base Case and Sensitivity Analysis Discounting Scenarios of LEa and Late Effect Morbidity 0% 3% 6% Base case (normal LE, no utility adjustment for late effect morbidity) $878 $1624 $2857 Normal LE plus utility adjustment for late effect morbidity $936 $1643 $2866 10% reduction in LE plus uti-

lity adjustment for late effect morbidity $1038 $1681 $2885 20% reduction in LE plus utility adjustment for late effect morbidity $1186 $1747 $2923 30% reduction in LE plus utility adjustment for late effect morbidity $1382 $1851 $2995 Abbreviations: DALY, disability-adjusted life-year; LE, life expectancy. a Decrements in LE.15,30 Cost of Childhood Cancer Treatment in El Salvador/Fuentes-Alabi et al Cancer January 15, 2018 395 Vivir and other foundations, the ability of HNNBB to achieve the cancer outcomes described in the current 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.[25] Abandonment of treatment, a complex phenomenon with multiple contributing factors, represents a common cause of treatment failure in many LMIC settings.[26-28] The parental foundation ASAPAC also was instrumental in decreasing local abandonment rates by funding accommodation; per diems; and, when necessary, medication for parents with limited incomes. Future costing studies in LMIC childhood cancer therefore must include costs associated with psychosocial and family support because they are integral determinants of survival outcomes.

Limitations of the costing component of the current 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 such as operating theaters, pathology, and radiation included the amortization costs of equipment. We did not have financial records to allocate the shared services of surgery, imaging, and radiotherapy, and relied instead on self-reporting by key personnel concerned. However these 3 components combined account for <5% of the overall treatment cost, and thus any resultant recall bias or misclassification is likely modest in size. Because we only examined costs incurred at a children's hospital, costs associated with the late effects of treatment among cancer survivors after the age of 14 years (at which time 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, traveling 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 often can be considerable for the family and can lead to treatment abandonment. [29] Despite these limitations, to the best of our knowledge the current study represents the most comprehensive costing of LMIC childhood cancer treatment to date.

Limitations of the cost-effectiveness analysis mainly are 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[15] in an American population that may not reflect cultural variations in health-related quality of life. In addition, although early mortality[20, 30] for childhood cancer survivors is well described in high-income countries, the question of whether these data are generalizable to LMICs is uncertain. To the best of our knowledge, there currently are no LMIC survivorship cohort studies with which to anchor our sensitivity analysis. Weaker health systems in LMICs would suggest that patients who develop early morbidity would die even earlier due to the lack of appropriate care, potentially making the results of the current study overly optimistic. Conversely, LMIC treatment protocols often are of lower intensity than those used in high-income countries due to less robust supportive care options (ie, infection control, intensive care, stem cell therapy). Late effects in LMIC survivors may thus be less severe compared with cohorts in high-income countries. It is important to note that sensitivity analyses increasing the theoretical burden of cancer survivorship in the current study did not change the cost-effectiveness of treatment. Finally, the generalizability of the current study results to other LMIC settings and other models of childhood cancer care delivery are unknown. Efforts to duplicate these analyses in other LMIC jurisdictions currently are underway.

The results of the current study provide a framework for reporting the costs of maintaining a comprehensive childhood cancer treatment center in an LMIC and have shown that investments in

this program are very costeffective. These results need to be duplicated in other LMICs, preferably of different income levels. The included tools developed for the current study may be useful in such duplications. Patient advocates and policymakers can use the current study results to inform national childhood cancer strategies that aim to improve childhood cancer outcomes in LMICs. Additional future work will identify costs for treating specific childhood cancer subgroups to help prioritize the allocation of resources.

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**Conflict of interest disclosures**

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