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A Cost-Effectiveness Analysis of a Pediatric Operating Room in Uganda☆

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ABSTRACT

This study examines the cost-effectiveness of constructing a dedicated pediatric operating room (OR) in Uganda, a country where access to surgical care is limited to 4 pediatric surgeons serving a population of over 20 million children under 15 years of age.
Methods: A simulation model using a decision tree template was developed to project the cost and disability-adjusted life-years saved by a pediatric OR in a low-income setting. Parameters are informed by patient outcomes of the surgical procedures performed. Costs of the OR equipment and a literature review were used to calculate the incremental cost-effectiveness ratio of a pediatric OR. One-way and probabilistic sensitivity analysis were performed to assess parameter uncertainty. Economic monetary benefit was calculated using the value of a statistical life approach.
Results: A pediatric OR averted a total of 6,447 disability-adjusted life-years /year (95% uncertainty interval 6,288–6,606) and cost $41,182/year (UI 40,539–41,825) in terms of OR installation. The pediatric operating room had an incremental cost-effectiveness ratio of $6.39 per disability-adjusted life-year averted (95% uncertainty interval of 6.19-6.59), or $397.95 (95% uncertainty interval of 385.41-410.67) per life saved based on the country's average life expectancy in 2015. These values were well within the WHO guidelines of cost-effectiveness threshold. The net economic benefit amounted to $5,336,920 for a year of operation, or $16,371 per patient. The model remained robust with one-way and probabilistic sensitivity analyses.
Conclusion: The construction of a pediatric operating room in Uganda is a cost-effective and worthwhile investment, endorsing future decisions to enhance pediatric surgical capacity in the resource-limited settings of Sub-Saharan Africa.

Introduction

As global efforts are galvanized to expand essential surgical access, pediatric surgery has been a relatively neglected area. Pediatric surgery has been named the "unborn child" of neglected disease,[1] especially in countries like Uganda where 48% of the population is under the age of 15. As many as 85% of pediatric patients in Africa are estimated to have a surgically treatable disorder by the age of 15.[2] Uganda faces a huge unmet need for pediatric surgical care, because there are currently only 4 qualified pediatric surgeons in the whole country to serve a pediatric population of 20 million.[3] The effective pediatric surgical coverage by the current health care system in Uganda amounts to a mere 3.5%.[4] This dearth of care of delivery is a result of a severe lack of resources,

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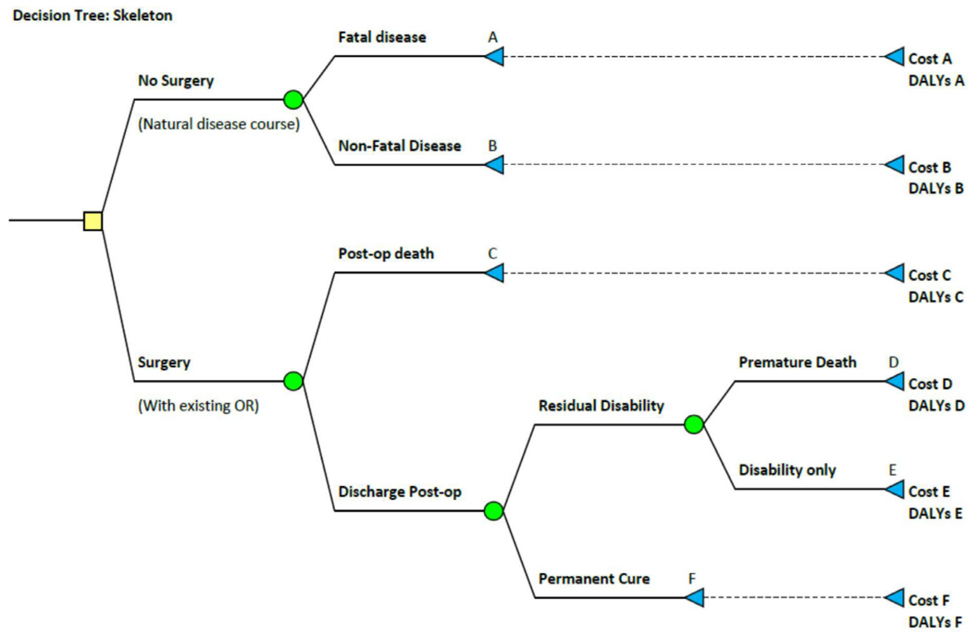

Fig. 1. The skeleton of the decision tree to model pediatric surgical diseases treated in the OR Square = Decision node between surgery and no surgery. Circle = chance nodes with probabilities attached to each branch. Triangle = end nodes with cost and outcomes for each possible scenario.

most remarkably in the surgical infrastructure. Demonstrably, no dedicated pediatric operating rooms (ORs)existed in the country until very recently.

In 2015, the ARCHIE Foundation, a nongovernmental organization (NGO) that provides support to the surgical needs of children in Africa, partnered with local health care providers to fund the construction of the first dedicated pediatric surgical OR in Uganda by donating surgical and anesthetic equipment.[5] The benefits of such a facility with a dedicated pediatric OR remain poorly described. No study has demonstrated the construction of a pediatric OR to be a justifiable use of scarce resources in a low-income setting with competing health care needs, especially when expensive upfront investment is required. With the need for better metrics to justify the development of surgical interventions in the global setting, the aim of this study was to quantify the disease burden averted by a pediatric OR to provide a better estimate about the cost and health consequences of furnishing a pediatric OR.

Cost effectiveness analysis (CEA) as an economic tool has been recently popularized by the Disease Control Priorities series[6] and adopted by the global surgery community.[7] In this context, CEA can help guide otherwise difficult decisions to channel limited resources toward the most efficient avenues. To date, there has been no cost-effectiveness study to quantify the cost proportional to health utility gained from a pediatric OR. This study hoped to determine the cost effectiveness of furnishing a pediatric OR by including the costs of the large-scale equipment donation.

Methods

The cost-effectiveness model

A decision tree base template was constructed to compare life trajectories that pediatric surgical patients take with or without surgical intervention, based on previously suggested methods.[7] To emulate realistic patient outcomes, the tree identifies a range of post-treatment scenarios, including immediate death and discharge, as well as long-term mortality, disability, and successful cure. The incremental deltas between OR costs and disease burden averted by surgical treatment and the counterfactual is the difference between the two branches at the decision node (Fig. 1). To simulate a year of OR operation, the annual disease burden averted is the sum of cumulative procedures done in a year. Model parameters include number of patients per year, number of procedures, OR equipment costs, and patient outcomes determined by severity of disease (in the form of disability weights) and probability of disease state.

Counterfactual

The counterfactual is defined as the natural course of disease in the absence of the pediatric OR, because prior to OR installation, no dedicated pediatric operating facility existed to provide curative treatment for these diseases in this area. The new pediatric OR allows surgery to proceed for all types of pediatric surgical conditions, especially for nonemergent and/or elective cases that still require treatment to avoid morbidity later in life. Additionally, nonsurgical curative treatment may not exist for some pediatric surgical diseases, especially in resource-limited settings, though nonoperative treatment can attenuate or minimize the disease burden. Pediatric surgical conditions often involve anatomic defects that require manual repair, so it is reasonable to assume that the natural course of disease is most likely in the setting of no surgery, even though this may be a simplification of the true breadth of treatment options. For patients with umbilical hernias, hydroceles, and other mild conditions that may resolve spontaneously later in life, the assumption was that the disease was substantial enough to cause lasting disability necessitating surgical correction in the first place. In these cases,a stable natural course of the disease over the patient's lifetime was used as the counterfactual scenario.

Parameters

We used the disability adjusted life year (DALY) as a metric to quantify the disease burden of each possible patient outcome in the decision tree. The final outcome metric was the incremental cost-effectiveness ratio (ICER), defined as $(\text{Cost}_{\text{OR intervention}} - \text{Cost}_{\text{natural disease course}}) / (\text{DALYs}_{\text{OR Intervention}} - \text{DALYs}_{\text{natural disease course}})$, and is presented as an absolute value in units US dollars/DALY averted. According to the guidelines of the World Health Organization (WHO), a cost-effective intervention