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## Orthopaedic Trauma Care in Haiti: A Cost-Effectiveness Analysis of an Innovative Surgical Residency Program

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### ABSTRACT

**Objective:** In an effort to sustainably strengthen orthopaedic trauma care in Haiti, a 2-year Orthopaedic Trauma Care Specialist (OTCS) program for Haitian physicians has been developed. The program will provide focused training in orthopaedic trauma surgery and fracture care utilizing a train-the-trainer approach. The purpose of this analysis was to calculate the cost-effectiveness of the program relative to its potential to decrease disability in the Haitian population. **Methods:** Using established methodology originally outlined in the World Health Organization's Global Burden of Disease project, a cost-effectiveness analysis was performed for the OTCS program in Haiti. Costs and disability-adjusted life-years (DALYs) averted were estimated per fellow trained in the OTCS program by using a 20-year career time horizon. Probabilistic sensitivity analysis was used to simultaneously test the joint uncertainty of the cost and averted DALY estimates. A willingness-to-pay threshold of \$1200 per DALY averted, equal to the gross domestic product per capita in Haiti, was selected on the basis of World Health Organization's definition of highly cost-effective health interventions.

**Results:** The OTCS program results in an incremental cost of \$1,542,544 ± \$109,134 and 12,213 ± 2,983 DALYs averted per fellow trained. The cost-effectiveness ratio of \$133.97 ± \$34.71 per DALY averted is well below the threshold of \$1200 per DALY averted. Furthermore, sensitivity analysis suggests that implementing the OTCS program is the economically preferred strategy with more than 95% probability at a willingness-to-pay threshold of \$200 per DALY averted and across the entire range of potential variable inputs. **Conclusions:** The current economic analysis suggests the OTCS program to be a highly cost-effective intervention. Probabilistic sensitivity analysis demonstrates that the conclusions remain stable even when considering the joint uncertainty of the cost and DALY estimates.

**Keywords:** cost-effectiveness, Haiti, injury, surgery, trauma.

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### Introduction

Every year, 20 to 50 million injury survivors are left permanently disabled, most often because of musculoskeletal injury [1,2]. The burden of disease preventable or treatable by surgery has been estimated to account for 11% of the total global burden of disease and injury [3,4]. Developing the supply and quality of surgical health workers has been identified by The Bellagio Essential Surgery Group as a vital solution to this growing problem [5]. As surgery becomes increasingly recognized as a public health priority, it is crucial to provide policymakers, nongovernment organizations, and aid foundations with information to effectively improve surgical care in lower- and middle-income countries (LMICs) [5–7]. This analysis models and calculates the cost-effectiveness of an innovative orthopaedic surgery training program to be implemented in Port-au-Prince, Haiti.

trauma care available to earthquake victims, as well as the general population, was made fully apparent [8–10]. In response to this public health need, the University of Maryland School of Medicine Division of Orthopaedic Traumatology in collaboration with Université de Notre Dame D'Haiti and the Haitian Ministry of Health developed the Orthopaedic Trauma Care Specialist (OTCS) program. The OTCS program will train Haitian medical school graduates who have completed 1 year of surgical training. After the OTCS residency, an abbreviated 2-year program, these specialists will possess the knowledge and ability to safely perform surgical interventions necessary to treat orthopaedic trauma conditions commonly seen in Haitian emergency departments and clinics, such as intramedullary nailing of long bone fractures and surgical management of musculoskeletal infection. This program utilizes a mentoring approach by visiting international orthopaedic surgeons, who will train Haitian faculty to independently implement the program with minimal international input within 5 years.

### Background

During the January 12, 2010, earthquake in Haiti, the already fragile Haitian health care system was inundated with extremity fractures resulting from the earthquake. The lack of sufficient orthopaedic

### Materials and Methods

#### Effectiveness assessment

The impact of the OTCS program was estimated by the effectiveness of the OTCS providers (OTCS Care) relative to the effec-

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**Table 1 – Disability weight scoring criteria.**

Score	Criteria: Disability weight
0.9	Needs assistance with activities of daily living such as eating, personal hygiene, or toilet use
0.8	Needs assistance with instrumental activities of daily living such as meal preparation, shopping, or housework
0.6	Limited ability to perform most activities in all the following areas: recreation, education, procreation, or occupation
0.4	Limited ability to perform activities in two or more of the following areas: recreation, education, procreation, or occupation
0.2	Limited ability to perform most activities in one of the following areas: recreation, education, procreation, or occupation
0.1	Limited ability to perform at least one activity in one of the following areas: recreation, education, procreation, or occupation

tiveness of conservative nonsurgical treatment that is presently available in Haiti, such as traction and casting (*General Care*). The impact of each of these interventions has been measured in terms of disability-adjusted life-years (DALYs) averted. DALYs are the standard measure of health utility selected by the World Health Organization and the World Bank. They are a measure of the sum of years of life lost and years lost to disability due to a disease or injury.

According to the criteria in Table 1 (modified from McCord and Chowdhury [11]), severe traumatic fractures have a disability weight of 0.2. This value can also be compared with the disability weight of long-term femur fractures described in the DALY literature as 0.272 [12]. Latin America and Caribbean regional health statistics demonstrate a high prevalence of long-

term femur fractures in the 15- to 44-year-old age group [13]. Because pediatric fractures are more commonly treated through conservative nonsurgical measures, fractures in patients younger than age 18 years have been excluded from this analysis. The average age of the population older than 18 years, calculated from the Haitian age distribution, is 37 years [14]. Based on this, the average length of time lived disabled for a nonpediatric patient with an untreated fracture, with 3% discounting and age weighting, is approximately 26 years (see Table 2). Therefore, the DALY value of the average nonpediatric fracture in Haiti equals 5.2 DALYs (see Table 3).

The DALYs averted by surgical intervention have been calculated by the method designed by McCord and Chowdhury [11] and subsequently revised by Bickler et al. [15] and Gosselin et al. [16]. The value of surgical care quantifies the ability of a treatment to alleviate the DALYs due to a disease or injury. This includes the success rate of the operation, its ability to mitigate the disability, as well as the procedure's underlying risk for potential negative surgical sequelae or necessary reoperation (Table 4) [15]. Unlike Gosselin et al. [16] though, we compare the value of surgical care with the value of general care in its ability to prevent lifelong disability, as opposed to no treatment, and therefore do not multiply the value of surgical care by the probability of long-term disability. Instead, we subtract the value of general care from the value of surgical care, as explained below, to yield the relative value of *OTCS Care*.

In the determination of the values associated with *OTCS Care* and *General Care*, the authors considered the fact that *OTCS* providers will primarily treat injuries that are associated with near-complete disability relative to the capacity to perform manual labor when treated nonoperatively, such as femoral shaft fractures, displaced ankle fractures, and both bones forearm fractures. Conversely, these result in little to no long-term disability when treated surgically by using modern techniques

**Table 2 – CEA model variables.**

Variables	Definition	Source	Mean	SD	Tested range
Annual budget	Annual budget to operate <i>OTCS</i> training program	Median annual budget of the 5-year program budget summary (see Table 5)	2,528,962	250,000	
Career span	Average number of years <i>OTCS</i> -trained provider will practice after training	Conservative presumption of <i>OTCS</i> graduation age of 30 and retirement age of 50	20	Function variable	15–25
Disability weight	Average fracture disability weight	McCord and Chowdhury DALY Scoring Criteria [11]	0.2	0.025	0.1–0.3
Salary difference	Estimated salary difference between <i>OTCS</i> -trained provider and unspecialized Haitian physician	Estimated on the basis of author and Haitian medical professional input	35,000	3,500	25,000–45,000
Patient life expectancy	Years of life potentially lived disabled (YLL)	The average age of nonpediatric population in Haiti older than 18 y is 37 y; Average YLL calculated by life expectancy with 3% discounting and age weighting as per DALY literature [20]	26	3	20–32
Operations per month	Average number of surgeries performed by an orthopaedic surgery provider per month	AAOS 2008 Statistics Report [21]	32	3	26–38
Value of general care	Measure of ability of nonsurgical intervention to reverse fracture disability	McCord and Chowdhury DALY Scoring Criteria [11]; International and Haitian medical professional input set the value between 5% and 50%	0.3	0.025	0.1–0.5
Value of surgical care	Measure of ability of <i>OTCS</i> surgery to reverse fracture disability, also accounting for risk of negative sequelae	McCord and Chowdhury DALY Scoring Criteria [11]; International and Haitian medical professional input set the value between 50% and 95%	0.7	0.05	0.5–0.9

CEA, cost-effectiveness analysis; DALY, disability-adjusted life-years; *OTCS*, Orthopaedic Trauma Care Specialist; YLL, years of life lost.

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