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Original Article

Cost-effectiveness of short-term neurosurgical missions relative to other surgical specialties

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Abstract

Background: Short-term surgical relief efforts have helped close some gaps in the provision of surgical care in remote settings. We reviewed the published literature on short-term surgical missions to compare their cost-effectiveness across subspecialties.

Methods: PubMed was searched using the algorithm ["cost-effectiveness" AND "surgery" AND ("mission" OR "volunteer")]. Articles detailing the cost-effectiveness of short-term surgical missions in low and middle-income countries (LMIC) were included. Only direct mission costs were considered, and all costs were converted into 2014 USD.

Results: Eight articles, representing 27 missions in 9 LMIC countries during 2006–2014, met our inclusion criteria. Latin America was the most frequently visited region. Per capita costs ranged from $259 for cleft lip/cleft palate (CL/CP) missions to $2900 for a neurosurgery mission. Mission effectiveness ranged from 3 disability adjusted life years (DALYs) averted per patient for orthopedic surgery missions to 8.12 DALYs averted per patient for a neurosurgery mission. CL/CP and general surgery missions were the most cost-effective, averaging $80/DALY and $87/DALY, respectively. The neurosurgical, orthopedic, and hand surgery missions averaged the highest costs/DALY averted, with the cost-effectiveness being $357/DALY, $435/DALY, and $445/DALY, respectively. All analyzed missions were very cost effective.

Conclusion: To date, this is the first study to assess the cost-effectiveness of short-term surgical missions across surgical specialties. Neurosurgical missions avert the largest number of healthy life years compared to other specialties, and thus, could yield a greater long-term benefit to resource-poor communities. We recommend that further studies be carried out to assess the impact of surgical missions in low-resource settings.

Key Words: Cost-effectiveness, global surgery, low and middle income countries, medical missions, neurosurgery

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INTRODUCTION

Twenty-eight percent of the global burden of disease is amenable to surgical intervention. The Lancet commission has estimated that 9 out of 10 people in LMIC do not have access to basic surgical care.[25] It is estimated that as a result of conditions needing surgical care, 16.9 million lives were lost worldwide in 2010; meanwhile, at least 77.2 million disability adjusted life year (DALY) could be averted by basic, life-saving surgical care.[25]

Interest in the provision of global surgery and the recognition that surgical and anesthesia care should be an integral component of a national health system has gained momentum over the past several years.[25] Short-term surgical missions are one way in which international surgical care has been provided by many decades. It is estimated that short-term medical missions cost at least $250 million annually, yet despite this notable cost expenditure, most short-term missions have no objective means of measuring their performance and effectiveness.[23]

Cost-effective analyses have become valuable tools that can aid decision-makers in identifying efficient ways to allocate resources for the provision of health care services.[16] However, there are currently no published studies comparing the cost-effectiveness of short-term surgical missions across the different surgical subspecialties. In our resource-limited society, this scarcity of studies highlights the need for further investigation into the effectiveness of surgery provided in such settings to guide further interventions.[33]

To open the discussion regarding this matter, we compare the published literature on the cost-effectiveness of short-term surgical missions, focusing on the differences in costs and effectiveness yielded by different subspecialties. We were particularly interested in determining how neurosurgical missions faired relative to the cost-effectiveness of less technologically demanding specialties. To the best of our knowledge, this is the first systematic review to compare the cost-effectiveness of short-term surgical missions across specialties. We hope that this study will foster further research regarding how to improve neurosurgical care in LMIC through short-term neurosurgical global missions.

MATERIALS AND METHODS

A systematic review of currently published literature on the cost-effectiveness of short-term surgical missions was conducted. The database PubMed was searched on March 2, 2016 using the algorithm ["cost-effectiveness" AND "surgery" AND ("mission" OR "volunteer")]. Bibliographies and related citations in PubMed were used to identify additional articles. All titles, abstracts, and full texts were reviewed to determine inclusion eligibility. Articles were included if they detailed the cost-effectiveness of a short-term surgical mission in a LMIC using standard metrics such as DALYs averted, cost per DALY, and total mission costs. Articles were excluded if they were not in English, contained cost-effectiveness data for only high-income countries, focused on cost-effectiveness NGO or mission hospitals in LMICs or specific surgical interventions as opposed to short-term missions, and did not provide all mission costs nor their related effectiveness.[1,2,4,7,13–15,18,19,24,30]

Only direct mission costs were considered in our analysis of mission costs. Indirect costs, including opportunity costs for international medical professions who volunteered their time, as well as costs incurred for transportation and medications by patients, were not considered in the analysis. To facilitate comparison between studies, cost estimates for each mission were converted into 2014 USD values using the consumer price index (CPI) published by the US Bureau of Labor Statistics.

The measure of the disease burden addressed by a surgical mission was the DALY, a standard metric of overall disease burden, expressed as the number of healthy years of life lost due to illness, disability, or early mortality used by the Global Burden of Disease Study.[27] Calculation of the DALY uses severity of the disease with standardized disability weight from the Disease Control Priorities project. In addition, the DALY can be age-weighted to take into account the greater social and economic contributions of people at midlife. Of note, only three out of the eight articles applied age weighting in their calculation of DALYs averted. Furthermore, DALYs can be discounted at 3% annually, thus valuing a year of life saved today at a greater value than a year of life saved in the future. Four out of the eight reviewed articles applied a discount rate of 3% per year.

The effectiveness of each surgical procedure was measured as the number of DALYs averted by each surgical procedure performed. The effectiveness of each surgical mission was calculated by calculating the sum total of all DALYs averted for the surgeries carried out throughout an entire mission. The cost-effectiveness of each surgical mission was then calculated by dividing the total direct cost of each surgical mission, recalculated by one of the authors (M.P.), by the total number of DALYs averted during the mission.

To assess the cost-effectiveness of each mission, the cost/DALY averted for each mission was compared to the country-specific 2014 GDP/capita (World Bank) where the mission was carried out. In accordance with the World Health Organization CHoosing Interventions that are Cost-Effective (WHO-CHOICE) project,

mission were considered very cost-effective if the cost/DALY of the mission was less than the GDP/capita of that country.[6] Missions that cost between one and three times the GDP/capita per DALY were considered cost-effective. If the mission cost more than three times the GDP/capita per DALY then the mission was not considered cost-effective.

RESULTS

We identified 8 full-length publications in our systematic review.[5,8,11,12,22,26,31,34] Table 1 summarizes the background characteristics of published short-term surgical missions. The articles represented a total of 27 missions, carried out in 9 LMIC countries over a period of 9 years (2006–2014). The analyzed articles included 1 neurosurgery publication describing 1 mission, 2 orthopedic publications describing a total of 9 missions, 2 general surgery publications describing a total of 4 missions, 2 of which were missions that focused on only inguinal hernia repair, while the other 2 provided a mix of general and gynecological surgeries, and 3 plastic surgery publications describing 13 missions, 12 of which were exclusively focused on cleft lip/cleft palate repair, and 1 of which focused on hand surgeries.

Latin America was the most frequently visited mission region among the analyzed literature; a total of 16 missions were carried out in 6 Latin American countries. Missions conducted in Latin America represented all surgical specialties for which published studies exist in short-term surgical brigade literature. Only 1 mission was carried out in Africa, and focused on cleft lip/cleft palate surgical interventions. A total of 10 missions were carried out in 2 Asian countries, and similar to Africa only focused on cleft lip/clef palate surgeries. Operation Smile organized all surgical missions carried out in Africa and Asia.

The length of all analyzed missions was between 7 and 8 days. Among all missions, the average patient age ranged between 3.19 and 47, with an age range of 0.3–85 years, for missions that provided this information. The neurosurgical mission had the youngest patient population while the general surgery mission focusing on inguinal hernia repair had the oldest patient population.

Table 2 summarizes total costs and cost-effectiveness of published short-term surgical missions analyzed in this study. Total mission costs ranged from nearly $4000 for CL/CP mission in Vietnam to just under $200,000 for an orthopedic surgery mission in Nicaragua and Dominican Republic. When costs were analyzed on a per patient basis, surgical missions that carried out surgeries to address a specific pathology, i.e., CL/CP in Vietnam and inguinal hernias in Ecuador, had the lowest average costs per patient. Meanwhile, missions that focused on multiple pathologies within one surgical specialty had the highest costs per patient. The neurosurgical mission in Guatemala had the highest per patient cost at $2900/patient. Two orthopedic missions had the next highest costs of $1610 per patient and $1304 per patient.

Table 1: Background characteristics of published short term surgical missions

Author	1st Author Country	#of Missions Reported	Mission Years	Institution	Interventions	Mission Location
Davis M *et al.*	US	1	2014	University of Michigan; Project Shunt	Neurosurgical	Guatemala
Chen AT *et al.*	US	1	2011	UCSF	Orthopedic	Nicaragua
Gosselin RA *et al.*	US	3	2009-2010	UCSF; Operation Rainbow	Orthopedic	Nicaragua (2), Dominican Republic (1)
Gosselin RA *et al.*	US	5	2010	UCSF; Operation Rainbow	Orthopedic	Haiti (4), Dominican Republic (1)
Egle *et al.*	US	2	2010-2012	Providence Hospital	General/Gynecological	Dominican Republic (2)
Shillcutt *et al.*	US	2	2010	Johns Hopkins, Operation Hernia	General - inguinal hernias	Ecuador (2)
Tadisina *et al.*	US	1	2006	Yale/Hopkins/University of Maryland	Plastics -Hand Surgery	Honduras
Magee *et al.*	US	1	2008	Operation Smile	Plastics - CL/CP	Hanoi, Vietnam
Magee *et al.*	US	1	2008	Operation Smile	Plastics - CL/CP	Ho Chi Minh City, Vietnam
Magee *et al.*	US	1	2008	Operation Smile	Plastics - CL/CP	Hanoi, Vietnam
Magee *et al.*	US	1	2008	Operation Smile	Plastics - CL/CP	Kien Giang, Vietnam
Magee *et al.*	US	1	2008	Operation Smile	Plastics - CL/CP	Hue, Vietnam
Magee *et al.*	US	1	2008	Operation Smile	Plastics - CL/CP	Vladimir, Russia
Magee *et al.*	US	1	2008	Operation Smile	Plastics - CL/CP	Chinandega, Nicaragua
Magee *et al.*	US	1	2008	Operation Smile	Plastics - CL/CP	Nyeri, Kenya
Moon *et al.*	US	1	2007	Johns Hopkins; Smile for Children	Plastics - CL/CP	Ng Hean, Vietnam
Moon *et al.*	US	1	2008	Johns Hopkins; Smile for Children	Plastics - CL/CP	Thanh Hoa, Vietnam
Moon *et al.*	US	1	2009	Johns Hopkins; Smile for Children	Plastics - CL/CP	Ca Mau, Vietnam
Moon *et al.*	US	1	2010	Johns Hopkins; Smile for Children	Plastics - CL/CP	Tuy Hoa, Vietnam

Table 2: Cost-effectiveness of published short term surgical missions

Author	Interventions	Mission Length	Av Pt Age	Total Pt #	Cost/Pt	DALYs/Pt	Cost-Effectiveness (Cost/DALY)	GDP/capita of Mission Country (World Bank 2014)
Davis M *et al.*	Neurosurgical	7 days	3.19 (0.5-15.2)	17	$2,900.61	8.12	$357.06	$3673.1 (Guatemala)
Chen AT *et al.*	Orthopedic	7 days	35.9 (3-70)	30	$748.25	1.38	$541.82	$1963.1 (Nicaragua)
Gosselin RA *et al.*	Orthopedic	Not Provided	12.5 (0.3-72)	117	$1,609.61	4.10	$392.34	$6163.6 (DR); $1963.1 (Nicaragua)
Gosselin RA *et al.*	Orthopedic	Not Provided	12.5 (0.3-72)	93	$1,303.74	3.51	$371.93	$824.2 (Haiti)
Egle *et al.*	General/ Gynecological	7 days	Not provided	71	$987.87	6.66	$151.03	$6163.6 (DR)
Shillcutt *et al.*	General - inguinal hernias	8 days	47 (4-85)	120	$125.12	5.33	$23.50	$6345.8 (Ecuador)
Tadisina *et al.*	Plastics -Hand Surgery	7 days	31 (0.8-68)	80	$581.52	1.31	$444.76	$2434.8 (Honduras)
Magee *et al.*	Plastics - CL/CP	7 days	Not provided	72	$94.13	8.72	$10.79	$2052.3 (Vietnam)
Magee *et al.*	Plastics - CL/CP	7 days	Not provided	103	$157.61	6.31	$24.99	$2052.3 (Vietnam)
Magee *et al.*	Plastics - CL/CP	7 days	Not provided	42	$169.05	5.84	$28.94	$2052.3 (Vietnam)
Magee *et al.*	Plastics - CL/CP	7 days	Not provided	74	$223.99	10.44	$21.45	$2052.3 (Vietnam)
Magee *et al.*	Plastics - CL/CP	7 days	Not provided	14	$252.35	4.82	$52.39	$2052.3 (Vietnam)
Magee *et al.*	Plastics - CL/CP	7 days	Not provided	33	$478.47	4.09	$117.12	$12735.9 (Russia)
Magee *et al.*	Plastics - CL/CP	7 days	Not provided	104	$693.39	4.23	$164.09	$1963.1 (Nicaragua)
Magee *et al.*	Plastics - CL/CP	7 days	Not provided	98	$475.20	1.65	$287.47	$1358.3 (Kenya)
Moon *et al.*	Plastics - CL/CP	7.5 days	8.3	202	$153.75	2.56	$60.07	$2052.3 (Vietnam)
Moon *et al.*	Plastics - CL/CP	7.5 days	8.3	181	$193.33	2.69	$71.85	$2052.3 (Vietnam)
Moon *et al.*	Plastics - CL/CP	7.5 days	8.3	222	$99.86	2.13	$46.97	$2052.3 (Vietnam)
Moon *et al.*	Plastics - CL/CP	7.5 days	8.3	203	$120.46	1.76	$68.50	$2052.3 (Vietnam)

The average number of DALYs averted for each patient undergoing surgery during each of the analyzed mission ranged between 1.31 and 10.44 DALYs per patient. Missions focusing on hand surgery, orthopedics, and CL/CP in Kenya resulted in the lowest average number of DALYs averted per patient, whereas the neurosurgical mission and 1 of the missions focusing on CL/CP in Vietnam resulted in the highest number of DALYs averted per patient. When analyzing the individual effectiveness of each surgical procedure, neurosurgical surgeries had both the highest and lowest DALYs averted per surgery compared to other surgical specialties, i.e. an endoscopic cyst fenestration averted 25.20 DALYs and an endoscopic 3rd ventriculostomy averted 23.80 DALYS while a dermoid cyst removal averted 0.10 DALYs.

All analyzed missions were deemed very cost-effective because the cost/DALY of each of the missions was less than the GDP/capita of the countries in which the missions were carried out. Specifically, we found the cost/DALY averted for CL/CP to be on average $79.55 across the 12 published missions. For general surgery mission, the average cost/DALY averted was $87.26, and it was further decreased to $23.50/DALY averted for the inguinal hernia mission. The neurosurgical, orthopedic and hand surgery missions averaged the highest costs/DALY, with the cost-effectiveness being $357/DALY, $435/DALY, and $445/DALY, respectively. Figure 1 averages and compares mission effectiveness and cost-effectiveness, across each subspecialty.

DISCUSSION

We acknowledge that our study has limitations. Because we analyzed already published data, we could not determine whether the data collection was similar among the articles that were compared. Given the differences in the setting and contexts in which missions were carried out, it may not be possible to combine data from all missions from a specific surgical subspecialty and extrapolate these findings to all surgical missions in that surgical field. Furthermore, there were some discrepancies between the DALYs calculations in the analyzed papers as some authors applied discounting and/or age-weighting while others did not. While discounting at 3%, annual rate is generally accepted, wide use of age-weighting in DALY calculation has been controversial. Moreover, the available cost-effectiveness literature on short-term surgical missions is limited, with only 8 studies currently published, and not all surgical fields were represented in our analysis.[5,8,11,12,22,26,31,34] Even within a surgical specialty, not all mission subcategories were represented in the currently published data.

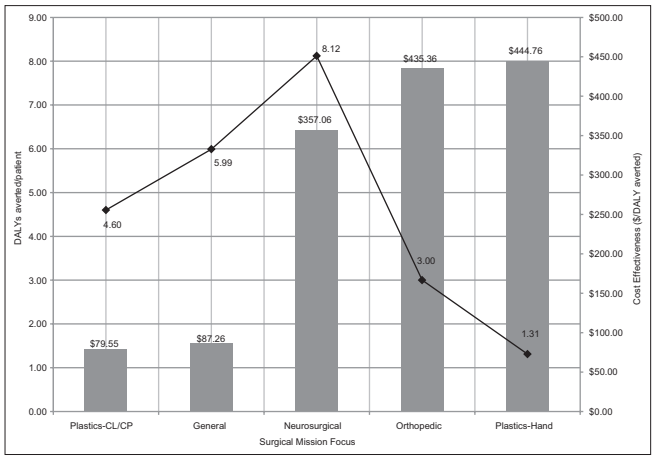

Figure 1: Per capita mission effectiveness and cost-effectiveness, by surgical specialty

Nonetheless, it is reasonable to discuss the trend evidenced by our data.

All publications on cost-effectiveness of surgical brigades came from US-based academic centers and nonprofits, and none of the authors were based at institutions in LMIC. This represents a worrisome trend seen in many fields of international cooperation. There is a tendency towards passivity in the physicians from the host country, and this could be attributed to various reasons, however, perhaps the one that can be changed by the visiting team is to plant the seeds of research interest in the hosts, emphasizing that research is not limited to complex issues linked to availability of biomedical equipment, and certainly involving the hosts in the elaboration of the manuscript is a promising first step towards human capacity building.

The majority of the published missions were conducted in Latin America, which can potentially be attributed to the proximity of US to Latin America making international collaborations easier. Operation Smile was the only organization that provided published cost-effectiveness literature on missions in Africa and Asia. Given that it is one of the most well-established surgical nonprofits in the world, it is likely it can provide the required capacity to carry out complicated surgeries in some of the most difficult to reach places. However, it is necessary to point out the possibility that the published literature on cost-effectiveness of short-term surgical missions does not accurately represent the distribution of missions. For instance, an analysis of mission carried out by member of the Foundation of International Education in Neurological Surgeries (FIENS) demonstrates preference toward volunteer sites in Africa, which may reflect increased need of that region.[29]

Costs of surgical missions vary by specialty. Interestingly, our study found that some of the biggest contributors to the high costs of neurosurgery and orthopedic surgery missions were transportation of international staff as well as their room and board. In addition, it has been argued that short-term surgical mission by outside surgeons are limited by suboptimal outcomes, unfavorable cost-effectiveness, and lack of sustainability, and thus appear to be beneficial only if no other option is available.[32] However, often in resource-poor settings, no local surgeons exist to provide the care necessary, and thus, travel of trained surgeons for provision of life saving surgeries is required. In such circumstances, it is necessary that transfer of surgical skills from international staff to local surgeons and ancillary staff takes place during these missions.[10] In ideal situations, governments should work in partnerships with NGOs and private sector providers to ensure sufficient education and training of their surgical workforce.[33]

Compared to the cost-effectiveness of short-term missions, surgeries offered through local hospitals are equally, if not more, cost effective. Gosselin and Heitto in 2008 have shown that a trauma hospital in Cambodia averts 1 DALY per US$87.[13] Moreover, when two MSF trauma hospitals were evaluated in Haiti and Nigeria, their cost effectiveness ratios were US$302 and US$218 per DALY averted, respectively.[14] Moreover, DCP3 has concluded that while basic essential procedures are likely to be cost-effective when delivered at any level of the health care system, the first-level hospital has been found to be especially cost-effective as a surgical delivery platform, coasting between $10–220 per DALY averted for all surgical care delivered.[3] Thus, while short-term surgical missions can temporarily fill the unmet surgical need gap and in general are cost-effective even compared to provision of surgical care locally, more resources should be devoted to the training and equipment provision of surgical teams working at first-level hospitals.[3]

Historically, neurosurgery has been viewed as too sophisticated and of little relevance to developing countries.[21] Moreover, DCP3 has stated that while first level district hospitals can offer selected emergency surgeries, surgeries associated with reproductive functions, other interventions such as surgeries for cardiovascular disease, cancer, organ transplantation, and neurosurgeries may be better suited for referral hospitals in LMICs, which are oftentimes ill-equipped and lacking in trained personnel.[28] The neurosurgeon-to-person ratio in sub-Saharan Africa has previously been determined to be 1:3.6 million individuals, with the ratio as low as 1 neurosurgeon per 9 million in some countries, short-term neurosurgical missions in Africa and other resource-poor settings may currently be one of the few options in such locations to deliver such a highly complex level of care, especially when no other surgical delivery platform is available.[20,32,33] Moreover, Haglund *et al*. have previously shown that enhancing neurosurgery in developing countries can have trickle

down effects and subsequently improve trauma, critical, anesthesia, neonatal, cancer care, as well as imaging and pathology.[9,17] This depends not only on the provision of high-tech equipment required for neurological surgeries but also on the existence of mobile teams of well-trained and highly versatile neurosurgeons who are able to adjust their techniques to resource limited environments.[21]

Compared to other missions, neurosurgical mission costs are some of the highest per patient likely because of the complex and technical nature of the interventions that are performed; however, they also avert the greatest number of healthy life years. It can be assumed that one reason for the high DALY/patient is the young patient population of the neurosurgical patients treated.[8] Because congenital neurosurgical conditions are treated at very young age, the maximum effect in terms of DALYs can be achieved with missions that address this group of pathologies. In addition, compared to other surgical specialties, neurosurgical conditions such as severe hydrocephalus are life-threatening, and thus, yield a higher disability weight to the patient should the patient not undergo treatment, thus contributing to the higher number of DALYs saved per patient.[35] In light of this, it can be assumed that despite their higher costs compared to general surgery and cleft lip/cleft palate missions, neurosurgical missions could yield a greater long-term benefit to communities than other surgical missions by providing the highest number of healthy life years to the population, thus creating a larger, healthier workforce to contribute to economic growth. On the whole though, it is necessary to still remember that mission data tends to underestimate costs because the cost of facilities and follow up care tend not to be included.[3]

Our study is the first of its kind to assess the cost-effectiveness of short-term surgical missions across multiple surgical specialties. We have demonstrated that although delivery of complex neurosurgical care in low-resource setting is challenging, neurosurgical missions avert the greatest number of healthy life years compared to other specialties, and thus, could yield a greater long term benefit to resource poor communities, especially if mission emphasize the importance of postoperative follow up and transfer of surgical skills to the local workforce. Given the lack of research that currently exists regarding the cost-effectiveness of short-term surgical missions, we recommend that further studies be carried out to assess the impact of surgical missions in low-resource settings.

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Conflicts of interest
There are no conflicts of interest.

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