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Is International Volunteer Surgery for Cleft Lip and Cleft Palate a Cost-Effective and Justifiable Intervention? A Case Study from East Asia

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Abstract
Background Although surgery provided by international volunteers is increasingly common in the developing world, there have been few assessments of the cost-effectiveness of these activities. In this context, this study covered 15 years of experience of one international nongovernmental organization, Smile for Children, in providing cleft lip (CL) and cleft palate (CP) surgical services in Vietnam.
Methods We analyzed the cost-effectiveness of the program and its contributions to building local capacity. To assess the cost-effectiveness of CL/CP surgery performed during Smile for Children's missions in Vietnam, we analyzed the data from four annual missions, from 2007 to 2010. According to the 2003 World Health Organization Guide to Cost-Effectiveness Analysis, we calculated cost per disability-adjusted life years (DALYs) averted with and without age weighting. For the data from the 2010 mission, we repeated the same calculation but with and without considering opportunity cost for labor.
Results The discounted cost per DALY averted averaged $68, ranging from $52 to $79 depending on the year of the mission. The average discounted cost per DALY averted with age weighting was $56 (range $43–$65). For the calculation that takes into account the volunteers' possible income loss as the labor cost of the mission in 2010, the cost per DALY averted without age weighting increased by 28 %, from $76 to $97; and the cost per DALY averted with age weighting increased by 27 %, from $63 to $80. Under all of these varying assumptions, the CL/CP program operated by Smile for Children is a cost-effective intervention using international criteria for cost-effectiveness.
Conclusions The contribution of the international volunteer surgical team to building in-country capacity is notable. It was achieved primarily through training Vietnamese surgeons during the mission trips and through sending these surgeons to Korea for training. Other staff, including anesthesiologists, were also trained; and equipment and supplies were provided.

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Introduction

Volunteer medical mission trips to less-developed countries have become an increasingly common way to provide health care services in low-income settings, particularly specialized surgical services. Significant financial resources are used for these activities. According to a recent study analyzing data from 543 medical mission organizations, the annual expenditure on short-term medical missions is conservatively estimated to be US$240 million [1]. Thus, questions about the cost-effectiveness of such ventures have been raised [2].

There have been few assessments of the cost-effectiveness of these activities. As far as we know, only one study has estimated the cost per disability-adjusted life years (DALYs) averted for cleft lip/cleft palate (CL/CP) surgery, and it concluded that CL/CP surgery is cost-effective [3]. Another study of the cost-effectiveness of surgical services provided by international volunteer teams was reported by Médecins Sans Frontières (MSF). The study mostly included trauma and burn patients in Sierra Leone. It reported $223 per DALY averted [4], making it similar in cost-effectiveness to the prevention of mother-to-child transmission of human immunodeficiency virus (HIV) infection [5].

One of the purposes of our study was to contribute to the evidence base regarding the cost-effectiveness of surgical services in low-income settings and, in particular, the cost-effectiveness of CL/CP surgery provided by international volunteer surgical missions. In addition to addressing the cost-effectiveness of CL/CP surgery provided by short-term volunteers, we addressed another issue concerning volunteer surgical mission trips—the possibility that they are stopgap approaches and do not build local long-term capacity. For instance, a recent review of this topic declared that "only in exceptional circumstances" are international health volunteers a defendable temporary measure given the under-used health personnel that exist in many developing countries [2]. Again, there is limited evidence in the peer-reviewed literature to explore this claim. To build on this limited evidence, we assessed an international nongovernmental organization (NGO)'s 15 years of experience in building local capacity for providing CL/CP surgical services in Vietnam.

Smile for Children: 15 years of experience in Vietnam

With an estimated 1.5 million births each year in Vietnam [6] and an incidence of CL/CP deformities of approximately 1 in 700 births, approximately 2,000 children are born every year with this deformity [7]. Only recently have Vietnamese health care providers developed the expertise to treat CL/CP patients. The few Vietnamese plastic surgeons with the ability to perform these operations are located in only 10 central hospitals, which are located in major cities. Consequently, in this country of 86 million inhabitants, it is still extremely difficult for poor families living in rural areas with a child afflicted with a CL or CP to access these services. According to discussions with Vietnamese surgeons, patients and their families generally have to pay in the range of US$200 for this surgery, and transportation and lodging expenses are not included. Even if patients are located in major cities, these costs are prohibitively expensive for many. Because of the limited access resulting from these financial and geographic barriers, international volunteer surgery mission teams still travel to Vietnam to care for untreated CL/CP patients.

To address this limited access, with the aim of providing high-quality plastic and reconstructive surgery for children with congenital anomalies in developing countries such as Vietnam and contributing to local medical education, Se-Min Baek started Smile for Children as a nonprofit NGO based in Seoul, South Korea in 1996. At that time, Dr. Se-min Baek was a leading plastic surgeon in Korea and was Professor and the Chairman of the Department of Plastic Surgery in Inje University College of Medicine in Seoul. Smile for Children relies on the voluntary efforts of plastic surgeons, anesthesiologists, nurses, and nonmedical volunteers from South Korea. It is not associated with any political or religious entity.

In 1996, Smile for Children carried out its first international voluntary surgical mission for patients with congenital anomalies, including CL/CP, in Hanoi, Vietnam. During this mission, 198 children received treatment. Since then, Smile for Children has provided surgical treatment for approximately 3,000 Vietnamese children. Each mission trip provides treatment for 120 to 200 patients over a 7- to 10-day period. Smile for Children mission teams operate not only on CL/CP patients but also on patients with other congenital anomalies or deformities and children needing plastic surgery because of scars from burns and other injuries.

Because modern equipment such as anesthesia machines and special plastic surgical instruments are not available in most local hospitals in Vietnam, a portion of the needed equipment is sent from Korea 2 months before departure of mission team. The team brings other equipment, and it purchases supplies and medication on site during the mission. To minimize the cost of supplies and equipment, the team selectively brings equipment from Korea that cannot be obtained in Vietnam or that is more expensive in Vietnam, and it purchases equipment and supplies in Vietnam that are inexpensive and easily acquired there. This approach helps reduce costs. Smile for Children annually purchases half of the required equipment and brings it to Vietnam from Korea. The new equipment is donated to the local hospital after the mission. Vietnamese health professionals are trained to use and maintain donated equipment at the end of the mission. The ultimate goal is for local health professionals to use and maintain the equipment independently after the volunteer team leaves.

Generally, one mission consists of three to five teams, and each team includes one fully qualified senior chief plastic surgeon and two other surgeons, some of whom are third-year surgical residents. Therefore, these missions also provide learning opportunities for Korean residents as well. The teams are always a mix of former team members and new volunteers. Since 1999, Vietnamese health care providers

have worked along with the Smile for Children volunteer surgical teams. This provides important training opportunities for local health care providers. Previous experiences and lessons are shared before each trip. After the trip, experiences and lessons learned are consolidated through written evaluations and personal or group meetings. The formation of three to five teams makes it possible to treat a larger number of patients during the same period of time.

The mission team divides the patient care process into three parts: preoperative care, operative care, and postoperative care. Anesthesiologists and surgical residents are in charge of managing the rooms where preoperative care and postoperative care are provided. The patients are first examined by a local surgeon at the time of admission and reexamined by one of the mission surgeons prior to surgery.

When the mission trips began in 1996, the local Vietnamese surgeons played a minor role in the Korean team's surgery. However, for the past few years now, Vietnamese surgeons are able to operate on CL/CP patients with minimal support from the Korean surgeons during the mission. The Vietnamese team of 10 to 12 members consists of local surgeons, anesthesiologists, and nurses. They function fairly independently and consult with the Korean team mostly on complicated cases. They also observe or assist on more complicated cases being managed by the Korean team to facilitate learning. The local staff and mission team members provide postoperative care together. Follow-up information regarding any postoperative complications that develop after the volunteer team has returned home is sent by the Vietnamese surgeons to Smile for Children.

Table 1 shows the number of procedures performed in Vietnam by Smile for Children since 1996. Overall, about half of the cases were for CL/CP surgery. A total of 1,580 children with CL and/or CP have undergone repair by Smile for Children since its initial trip in 1996.

Building surgical capacity in Vietnam

As surgery provided by international volunteers is increasingly common in the developing world, recent articles have stressed the need for international volunteer surgical mission teams to strengthen local surgical capacity by training local surgeons while at the same time directly providing surgical services [8, 9]. In addition, there is consensus that donors and developed countries need to put more effort into training local leadership for CL/CP surgery instead of providing only curative care [10]. One article describing 15 years of CL/CP surgery experience in Latin America emphasized the importance of collaborating with local plastic surgeons and educational support for the local plastic surgery society [11].

Smile for Children also has made efforts to improve the local capacity of health care workers and facilities to provide high-quality plastic and reconstructive procedures in Vietnam. From the outset of these mission trips, Smile for Children provided learning opportunities for Vietnamese surgeons by including them as members of the operative team so surgical techniques could be transferred. Also, the Korean team held at least one half-day symposium during every mission to provide additional training for the local surgical team. In addition to the training provided to Vietnamese surgeons and other staff during the mission, Smile for Children has brought six junior surgeons from Vietnam to Seoul National University Bundang Hospital for training in craniofacial surgery, including CL and CP repair, under the guidance of one of the authors (R.B.). Training opportunities for these procedures are still limited in Vietnam. Beginning in 2002, Smile for Children brought six junior surgeons from Vietnam to Seoul Bundang Hospital for training in advanced surgical techniques in CL/CP repair as well as for additional training in general surgery. After completing 6–12 months of intensive training, they return to Vietnam and become a partner to support Smile for Children's activities in Vietnam. They also perform surgery independently when the mission team is not in Vietnam. More importantly, they have become academic leaders in the provision of surgical education at major training hospitals. These academic leaders are now in the process of establishing Vietnam's first plastic surgery academic association.

Collaboration with Vietnamese health institutions

Health care providers from the Hanoi 108 Military Hospital have participated in every mission of Smile for Children since 1998. The Hanoi 108 Military Hospital team consists of plastic surgeons, anesthesiologists, and nurses. Most of the doctors on the team have also trained in Korea through a Smile for Children's training program. The Hanoi 108 Military Hospital team travels to the mission site prior to arrival of the Korean team to examine the capacity of the local hospital. The Hanoi 108 Military Hospital team prepares the surgical setting and screens patients. This enables the Korean teams to begin surgery as soon as they arrive, thus optimizing efficiency and reducing costs. If any complications or problems occur after the Korean team returns home, they are reported to the Hanoi 108 Military Hospital team so appropriate further care can be provided in consultation with the Smile for Children staff, either by the Hanoi 108 Military Hospital or by the local hospital where the patients were initially treated.

In Vietnam, newborns with congenital anomalies that cannot obtain appropriate surgical treatment are reported to

Table 1 Number and types of patients operated on during Smile for Children missions, 1996–2010

Year and location	No. of patients with cleft lip repair	No. of patients with cleft palate repair	No. of patients with a repair for other diagnoses[a]	Total no. of patients
1996 (Hanoi)	108	72	13	193
1997 (Hue)	98	65	87	250
1998 (Hanoi)	105	47	3	155
1999 (Hochimin)	73	62	116	251
2000 (Hanoi)	71	51	75	197
2001 (Hochimin)	36	27	96	159
2002 (Thai Nguyen)	63	43	134	240
2003 (My The)	52	41	64	157
2004 (Bac Ha)	61	33	59	153
2005 (Bac Ninh)	38	43	94	175
2006 (Ninh Binh)	31	24	79	134
2007 (Ng Hean)	18	61	123	202
2008 (Ca Mau)	38	50	93	181
2009 (Thanh Hoa)	18	56	148	222
2009 (Hanoi)	13	20	2	35
2010 (Tuy Hoa)	22	40	141	203
Total	845	735	1,327	2,907

[a] Other diagnoses include hand deformities, ptosis, scar contractures, burn scars, ear deformities, hemangiomas, and revision of previously repaired cleft lip/palate (CL/CP), usually by a local untrained surgeon

a government registry, and the government then assigns each patient for treatment by an international visiting surgical team such as Smile for Children. Generally, patients with low socioeconomic status or those living in rural areas are assigned to undergo surgery by international surgical teams. The Hanoi 108 Military Hospital team also uses the government register system to analyze the local demand and then matches the current need to Smile for Children's capacities.

Understanding the political, social, and cultural context is a challenge for all international volunteer surgical missions. The communist regime in Vietnam closely regulates all foreign activities, particularly in rural areas. The partnership that Smile for Children has developed with the government has helped it to avoid time- and cost-consuming problems.

Materials and methods

Case material

In this study, 303 CL/CP cases from four Smile for Children's missions from 2007 to 2010 have been included in the cost-effectiveness analysis. Because financial data for the years prior to 2007 were incomplete, the analysis has been carried out for the period from 2007 to 2010. Data for the 33 cases treated during the 2009 mission to Hanoi were not available, so these patients have not been included in the analysis. The same treatment protocol has been in place since the first mission in 1996. We have no reason to believe that costs were significantly different in previous years except for changes due to inflation.

Few patients operated on by Smile for Children need a secondary revision. However, the Smile for Children team conducted secondary revision surgery on a few patients who had had suboptimal results following the initial repair, often performed by less-skilled local surgeons. Because the baseline disability of these patients may differ from that of untreated cases, the appropriate disability weight may differ as well; but we have no way of determining that. Therefore, we have excluded these cases from the analysis.

Cost-effectiveness analysis using disability-adjusted life years

Cost-effectiveness analysis (CEA) is a tool to assess the cost of achieving quantified health effects through a specific intervention [12]. CEA is increasingly important in decision-making for public health resource allocation in all societies, whether rich or poor [13]. DALYs have been utilized most widely to reflect the burden of premature mortality and disability for specific diseases. Total DALYs for each cause, age, and sex group are calculated as the sum of "healthy" years lost due to nonfatal health conditions (referred to as years lost due to disability, or YLD) and due to premature mortality (YLL) [14].

Discounting

Discounting is the standard economic method for giving greater value to a current benefit than to a similar benefit

obtained in the future. Although discounting of future health effects has aroused controversy, there is consensus that quantitative measures of the current value of health benefits (e.g., DALYs averted) that are estimated to accrue in the future should be discounted [15]. The standard approach commonly used is to apply a 3 % per year discount rate to estimate the current value of future health benefits [16].

Age weighting

When DALYs were first developed, it was assumed that a greater weight should be assigned to a year of midlife compared to a year of life at the beginning or at the end of the life course. This was because of the greater social and economic importance of people at midlife [17]. Under this assumption, age weights are zero at birth, reach a maximum at age 25, and then gradually decrease to zero as age advances. Standard age weighting gives a maximum age weight of 1.52 at age 25 years with a prime age range (during which the weight is >1) of 8.4 to 54.2 years. This weighting is controversial, however, for moral and ethical reasons [18]. Opponents argue that age weights are unacceptable because from a moral perspective every year of life is of equal value regardless of the age of the person. Other opponents argue that the current age weights do not well reflect actual social values. Our study computes discounted DALYs averted both with and without age weighting.

DALY calculations for a patient with a specific condition

DALYs make it possible to quantify with a single number the combined burden of a disease or condition from premature mortality and disability. DALYs also provide a useful tool for quantifying the reduction in the burden of disease from specific interventions and programs. To assess the impact of CL/CP surgery performed by Smile for Children's mission teams, we estimated the number of DALYs averted. The number of healthy years of life lost because of disability (YLD) is obtained by multiplying the average duration of the condition (until remission or death occurs) by a disability weight that quantifies the estimated decrement in health due to a disease or condition [14]. These disability weights have been created by a panel of experts based on their opinion of the impact of each specific type of disability on one's life. For instance, leg amputation is assigned a disability weight of 0.30, and complete blindness in both eyes is assigned a disability weight of 0.60 [19]. The number of healthy years of life lost due to premature mortality (YLL) is a function of the life expectancy at the time of death and the expected duration of life at that age. (In this analysis, we assumed that there are not years of healthy life gained by CL/CP surgery.) The number of healthy years of life lost to disability is a function of the life expectancy at the age at which the disability occurred and the weight applied to the disability.

Calculation of costs

The cost analysis includes both direct and indirect costs. More specifically, the direct costs include the volunteer team members' lodging and food, surgical supplies and medicines, administrative staff costs for mission trip preparation, and transportation and salary costs for Vietnamese health providers from Hanoi 108 Military Hospital. Administrative costs include 1 month of administration, which is partly composed of two residents spending approximately 20 % of their time during the month prior to the visit and one Vietnamese surgeon visiting the host hospital in advance for 1 to 2 days. Indirect costs include patients' hospitalization fees, food and transportation costs, and other miscellaneous expenses. Costs incurred in Vietnamese currency (the dong) were converted to Korean currency (the won) and then all costs were converted to US dollars using the exchange rate 3 months prior to the implementation of each mission. We did not include any costs related to the use of the hospital space during the mission or the depreciation of hospital facilities.

To compensate for the extra costs incurred by each local hospital facility, the mission team donates any remaining medical supplies to that facility (usually about 20 % of surgical supplies and medications purchased by the team). According to the surgeons of Smile for Children, there is no significant difference in utilization of surgical supplies and medicines for the various types of surgical procedures they perform. Therefore, the cost-effectiveness analysis we carry out assumes that the average cost per patient is the same regardless of the procedure.

Our study used two approaches to calculate the dollar value of the volunteers' labor. The first approach considered the volunteers' opportunity cost for mission participation to be the income that would have been earned had they spent that time working in South Korea. The second approach considered it to be zero, the same as if it were a vacation. Because it was difficult to judge which approach was better, we used both and carried out separate analyses with each approach. The participants' salary information was available for the mission of 2010 only. Therefore, we calculated the cost-effectiveness including the opportunity cost only for the mission in 2010. The average annual salary of participants for Smile for Children's mission of 2010 was $46,670. The opportunity cost for labor during the mission was calculated to be the sum of the volunteers' income loss for five working days.

Estimation of life expectancy among patients with corrected and uncorrected cleft lip and palate

There are no data regarding the long-term mortality of untreated and treated CL/CP patients in Vietnam. So as not to overstate our cost-effectiveness estimate, we assumed in our calculations that there is no mortality benefit from CL/CP repair. In one long-term study from Denmark, there was a 1.4–1.8-fold increased long-term mortality among CL/CP patients (all of whom had undergone surgical repair) apparently as a result of an increased mortality risk from all causes of death rather than as a direct result of the CL/CP condition, probably due to associated genetic aberrations [20]. This is likely to be the case among Vietnamese children as well, and repair of CL/CP did not reduce this risk. It is also important to point out that there was no operative mortality among the patients included in this study, and there were no deaths identified among the patients in the study over the 16 year study period.

Disability weighting

To calculate the degree of disability associated with CL/CP, the disability weight from the Disease Control Priority (DCP) life table was used [14]. The disability weight for an uncorrected CP is assumed to be 0.231, and the residual disability for a corrected CP is 0.015. The disability weight for CL is 0.098, and residual disability for corrected CL is 0.016. Therefore, surgical repair reduces the disability weight by 0.082 for CL patients and by 0.216 for CP patients. For the patients who had both CL and CP, the disability weight for CP was used. Standard life expectancies for each age-sex group were assigned from a current life table for the general Vietnamese population [21].

Among the CL/CP patients who received surgery from Smile for Children, 129 patients were older than 5 years. The Burden of Disease life table from the most recent disease control priority project assumes that the benefits from surgery (from the perspective of DALYS averted) for patients >5 years of age are zero [14]. However, from the perspective of patients, family, and medical providers, there is ongoing benefit of CL/CP surgeries on patients even after the patient reaches 5 years of age. A recent study analyzing cost-effectiveness of CL/CP surgery suggests that surgical repair for CL/CP patients >5 years should have an impact on alleviating lifetime disability [3]. Therefore, they use a modified Burden of Disease life table to reflect the lifetime effect of CL/CP surgery. Our analysis used the same method and extended the same disability weight for patients once they exceed 5 years of age.

Assumptions for the cost-effectiveness analysis model

Our analysis uses the following assumptions.

1. The cost for each case was the same.
2. When a patient had both a CL and a CP, the disability weight for CP was used to calculate the number of DALYs averted.
3. The salary costs for Korean volunteers were calculated in two ways (zero and equivalent to lost income). The salary costs for Vietnamese health care providers were calculated from their monthly income.
4. The value of equipment and supplies that did not need to be purchased was not included as an expense.
5. The host hospital's indirect costs (e.g., electricity, water, security) were assumed to correspond to the value of the equipment and supplies brought by the team that were not used (and were left as a donation to the hospital), so in effect these expense and cost items—the hospital's indirect costs and the value of the equipment and supplies donated by the mission team—cancel each other out.

Formula for calculating DALYs averted (with and without age weighting) as a result of surgery

The formula for computing DALYs is the following:

$$\mathrm{DALY} = \mathrm{YLL} + \mathrm{YLD}$$

According to the guideline for burden of disease estimation from World Bank and World Health Organization [16], the formula for calculating individual YLL is:

$$YLLs(r,K) = P\left\{\frac{KCe^{ra}}{(r+\beta)}\left\{e^{-(r+\beta)(L+a)}[-(r+\beta)(L+a)-1] - e^{-(r+\beta)a}[-(r+\beta)a-1]\right\} + \frac{1-K}{r}\left(1-e^{-rL}\right)\right\}$$

where P is the probability of death, K is the modulator of the age weight (1 or 0), C is the mathematical constant (0.1658), and r is the discount rate (3 %). α is age at death, β is the parameter from the age weighting function (0.04), e is the natural logarithm root (2.72), and L is the life expectancy.

Without discounting, this formula is simplified as:

$$YLLs(0,K) = \frac{KCe^{-\beta a}}{\beta^2}\left[e^{-\beta L}(-\beta(L+a)-1) - (-\beta a - 1)\right] + [(1-K)(L)]$$

The parameter K indicates whether age weighting is applicable ($K = 1$) or not ($K = 0$). C is the age-weighting correction constant. The Global Burden of Disease (GBD)

standard value for this is 0.1658 [21]. β is the parameter from the age-weighting function. The GBD standard value for this is 0.04. L is the life expectancy derived from the Vietnamese life table. P is the probability of death for each cause (which in this study is 0), for each age group by sex [22].

Similarly, the formula for calculating individual YLD is:

$$YLDs(r,K) = DW\left\{\frac{KCe^{ra}}{(r+\beta)^2}\left\{e^{-(r+\beta)(L+a)}\right.\right.$$
$$\left.[-(r-\beta)(L+a)-1]-e^{-(r+\beta)a}[-(r+\beta)a-1]\right\}$$
$$\left.+\frac{1-K}{r}\left(1-e^{-rL}\right)\right\}$$

Without discounting, this formula is simplified as:

$$YLDs(0,K) = DW\left\{\frac{KCe^{-\beta a}}{\beta^2}\left[e^{-\beta L}(-\beta(L+a)-1)\right.\right.$$
$$\left.\left.-(-\beta a-1)\right]+[(1-K)(L)]\right\}$$

where DW is disability weight, K the modulates age weight inclusion (1 or 0), C the mathematical constant (0.1658), r the discount rate (3 %), α the age at death, β the parameter from age weighting function (0.04), e the natural logarithm root (2.72), L is the years lived with disability.

Calculation of cost per DALY averted

The average cost for each case was calculated by dividing the total costs of the mission by the number of total cases performed during each mission. (This includes patients with other types of congenital anomalies as well). The total cost for all CL/CP patients was obtained by multiplying the number of CL/CP cases by the average cost per patient. Then, the sum of total costs for the CL/CP cases was divided by the number of discounted DALYS averted (with and without age weighting) to calculate the cost per DALY averted as a result of CL/CP surgery. The data and calculations are available from the authors.

International volunteer surgical missions used for cost-effectiveness analysis

To assess the cost-effectiveness of CL/CP surgery performed during Smile for Children's missions in Vietnam, we used data from the four missions from 2007 to 2010. The mission sites were four rural areas in Vietnam: Ng Hean, Than Hoa, Ca Mau, Tuy Hoa. The average mission duration was 7.5 days, and the average number of patients treated during each mission was 202. CL/CP cases accounted for 38 % of all of the cases treated during these four missions. Other congenital conditions and burn scars accounted for the rest.

Results

Overall, the average cost per case was $335, ranging from $271 to $363 depending on the year of the mission (Table 2). The costs incurred by patients and their families for food, transportation, and hospitalization were the single largest category of costs (34 % of the total) followed by the costs for surgical supplies and medicine (32 %) brought from Korea. Transportation and accommodation costs for the Korean team members constituted 28 % of the total costs.

The average discounted cost per DALY averted over the 4 year period was $68, ranging from $52 to $79 depending on the year of mission. The average discounted cost per DALY averted with age weighting was $56, ranging from $43 to $65 (Table 3). When considering volunteers' possible income loss as a labor cost of mission in 2010, the cost per DALY averted without age weighting increased by 28 %, from $76 to $97, and the cost per DALY averted with age weighting also increased by 27 %, from $63 to $80 (Table 4).

Discussion

The results of this study indicate that the average cost-effectiveness of CL/CP surgery performed by the Smile for Children volunteer surgical mission team for children in Vietnam is in the range of $56 to $97, depending on whether age weighting is used and on whether the salary "opportunity costs" of the Korean surgeons is counted as "lost" income or as volunteer vacation time. Based on currently accepted international criteria, this intervention is highly cost-effective. We make this claim based on two lines of argument. The first is that our estimate of the cost per DALY averted for CL/CP surgery is less than the estimates of cost per DALY averted for a number of other standard public health programs. Second, the cost per DALY averted through CL/CP surgery is within the range of cost-effectiveness defined by the World Health Organization (WHO) and the World Bank, as described below.

As shown in Table 5, the cost-effectiveness of CL/CP surgery is in the range of that of standard public health interventions in the developing world, such as tuberculosis programs, family planning programs, HIV/AIDS programs, and nutrition programs [23]. It is even more cost-effective than family planning programs ($117 per DALY averted) or management of lower respiratory infection ($129 per DALY averted).

Table 2 Costs of international volunteer surgery mission trips by Smile for Children from South Korea to Vietnam, 2007–2010 and average cost per case

Year and place of mission	Transportati-on, hotel, food costs	Costs of medical supplies	Costs incurred by patient and local hospital	Labor costs (for Vietnam-ese staff)	Administrative staff costs	Total costs	Average cost per case
2007 (Ng Hean)	$7,044	$10,429	$8,148	$282	$1,298	$27,200	$344
2008 (Thanh Hoa)	$9,025	$11,668	$9,167	$350	$1,614	$31,824	$362
2009 (Ca Mau)	$4,843	$4,529	$9,371	$240	$1,107	$20,090	$271
2010 (Tuy Hoa)	$7,290	$5,919	$8,081	$220	$1,014	$22,524	$363
Average cost (% of total costs)	$7,051 (28 %)	$8,136 (32 %)	$8,692 (34 %)	$273 (1 %)	$1,258 (5 %)	$25,409 (100 %)	$335

In US dollars

Table 3 Cost per DALY averted by cleft lip and cleft palate surgery (in US dollars)

Year and place of mission	Without age weighting		With age weighting	
	No. of DALYs averted	Cost/ DALY averted	No. of DALYs averted	Cost/ DALY averted
2007 (Ng Hean)	422	$65	517	$53
2008 (Thanh Hoa)	402	$79	487	$65
2009 (Ca Mau)	388	$52	472	$43
2010 (Tuy Hoa)	296	$76	357	$63
Average	377	$68	458	$56

DALYs disability-adjusted life years

Table 4 Cost per DALY averted by cleft lip/cleft palate surgery with and without consideration of opportunity costs for labor (in US dollars)

Year and place of mission	Without age weighting		With age weighting	
2010 (Tuy Hoa)	No. of DALYs averted	Cost/ DALY averted	No. of DALYs averted	Cost/ DALY averted
Without opportunity cost	296	$76	357	$63
With opportunity cost	296	$97	357	$80

According to the Disease Control Priority Project (DCPP) of the WHO and the World Bank, the use of discounted DALYs without age weighting is suggested as the most appropriate measure of disease burden [14]. Therefore, we compared this cost-effectiveness estimate ($68 per DALY averted) to the cost- effectiveness of other interventions. Following the recommendations of the Commission on Macroeconomics and Health, the WHO's strategy called Choosing Interventions that Are Cost-Effective (WHO-CHOICE) uses the gross domestic product (GDP) per capita as a reference indicator of cost-effectiveness. Highly cost-effective interventions are those with a cost per DALY averted of less than the GDP per capita; cost-effective interventions are one to three times the GDP per capita; and cost-ineffective interventions are those that are more than three times the GDP per capita [24]. Vietnam's GDP per capita is $1051 [25]; therefore, a cost-effectiveness of $68 per DALY averted means that CL/CP surgery performed by Smile for Children is a highly cost-effective intervention.

The World Bank (1993) used more stringent criteria. The World Bank concluded in 1993 that $150 per DALY averted is a cost-effective intervention and $25 per DALY averted is a highly cost-effective intervention for low-income countries [25]. Considering the inflation effect since 1993, the adjusted threshold value in 2010 US dollars is $37 for highly cost-effectiveness and $223 for cost-effectiveness [26]. Therefore, the results of our study suggest that CL/CP surgery meets the criteria for a cost-effective intervention in low-income countries.

Because of the small number of studies of the cost-effectiveness of surgery done by short-term volunteer surgical mission teams, it is difficult to find comparable outcomes in similar settings. One study calculating the cost-effectiveness of CL/CP surgery during short-term missions of Operation Smile, a US-based humanitarian organization, estimated a cost-effectiveness of its mission trips to be between $7 and $96 per DALY averted (average of $34) [3]. However, their study focused only on the direct costs incurred by Operation Smile and the health care providers during the mission. It did not include the costs incurred by patients, the family, or the mission site hospital (as we did in our study), nor did it include lost income opportunity costs. In our case, we estimated that indirect costs to cover the patient's hospitalization, medicine, food, and transportation are a significant part (34 %) of the total costs for each case. Also, including income opportunity costs increased the total cost by 27–28 %. However, both studies come to the same conclusion: CL/CP surgery performed by international short-term volunteer mission teams can be cost-effective.

Table 5 Cost per DALY averted for specific health interventions (in US dollars) [30]

Disease/condition	Intervention	Cost (US$)/ DALY	Cost (US$)/ DALY range
Tobacco addiction	Taxation causing 33 % price increase	$22	–
Adolescent health and nutrition	School health and nutrition programs	$37	–
HIV/AIDS	Peer and education programs for high-risk groups	$37	$6–$68
Onchocerciasis	Ivermectin	$37	–
Trachoma	Trichiasis surgery	$39	–
Underweight children	Child survival program with nutrition component	$42	–
Diarrheal disease	Water sector regulation with advocacy where clean water supply is limited	$47	–
Cleft lip/cleft palate[a]	Cleft lip/cleft palate surgery by Smile for Children (reported in the current study)	$68	$52–$79
Tuberculosis (endemic)	BCG vaccine	$68	$55–$82
Tuberculosis (epidemic, infectious)	Directly observed short-course chemotherapy	$102	$15–$189
Unwanted pregnancy	Family-planning programs	$117	–
Emergency medical care	Staffed community ambulance	$120	$60–$179
Lower acute respiratory infections (nonsevere)	Case management at community or facility level	$129	$50–$208
Problems requiring surgery	Surgical ward or services in district hospital or community clinic	$136	$54–$217
Diarrheal disease	Construction and promotion of basic sanitation where facilities are limited	$141	$11–$270
HIV/AIDS	Treatment of opportunistic infections	$156	$3–$310
Cataract	Extra-capsular surgery	$183	–
HIV/AIDS	Mother-to-child transmission prevention	$192	$7–$377
Tuberculosis (epidemic, latent)	Isoniazid treatment	$197	$45–$348
Tuberculosis (epidemic)	Management of drug resistance	$207	$201–$212
Undernutrition and malnutrition	Sustained child health and nutrition program	$225	–
Tuberculosis (endemic, infectious or noninfectious)	Directly observed short-course chemotherapy	$301	$84–$551
Tuberculosis (endemic)	Management of drug resistance	$318	$208–$429

HIV/AIDS human immunodeficiency virus/acquired immunodeficiency syndrome, *BCG* bacille Calmette-Guérin (vaccine)

[a] Results from the present study

Cost-effectiveness analysis of surgical interventions in developing countries

According to the best current expert opinion, surgically treatable conditions account for 11 % of the world's total DALYs [27]. However, from the global public health perspective, surgery has generally been considered a cost-ineffective intervention relative to other standard public health interventions in developing countries. To prioritize which surgical procedures are effective public health interventions in the developing world, robust evidence regarding the cost-effectiveness of specific types of surgical interventions is necessary.

Recent research has demonstrated that essential surgery for obstetric and traumatic conditions at first-level referral hospitals in several low-income countries is more cost-effective than previously thought. A cost-effectiveness analysis study performed in a small rural hospital in Bangladesh estimated that the cost of obstetric surgical interventions was $11 per DALY averted, which compares favorably with other standard public health interventions, such as an HIV high-risk group education program ($37/DALY), trachoma surgery ($39/DALY), or BCG immunization ($68/DALY) [28]. Other studies suggest that the surgical treatment of common surgical conditions in developing countries (e.g., hernia repair, trauma management) is sufficiently cost-effective to be part of a basic cost-effective package of health services in developing countries. A recent study from Sierra Leone estimated that surgical interventions cost $38 per DALY averted [29]. A study from Cambodia estimated that surgical treatment for trauma costs $78 per DALY averted [30].

A comprehensive measurement of the impact of an intervention on long-term disability is as critical as the impact on mortality in terms of assessing the intervention's

cost-effectiveness [31]. Thus, our study is one of the few that provides evidence of the cost-effectiveness of a surgical procedure for a chronic condition, thereby strengthening the evidence for a stronger role for surgical services in developing country health programs.

Additional benefit of long-term capacity building

International surgical volunteer mission trips have been criticized for their lack of sustainability and their creation of dependence on external resources. One recent survey, for instance, reported that the contribution of international health volunteers to developing local human resource capacity in the developing world is limited [2].

Long-term collaborations with strong partners can have a sustainable impact by strengthening local capacity [32]. Contrary to the common belief that international volunteer surgical missions have only a short-term impact, one program of volunteer surgical mission teams for CL/CP surgery in the Ben Tre province of South Vietnam contributed to lowering the age at first operation and reduced the number of adult patients with this condition over an 11 year period [33]. At present, partnerships now exist between a growing number of academic medical centers in North America and teaching hospitals in developing countries to adapt short-term collaborations to local needs for training as well as for clinical care through mutual learning processes [34]. Well-structured surgical education trips sponsored by international NGOs have, for example, successfully introduced pediatric hand and burn reconstructive surgery techniques to Vietnamese surgeons [35].

In Smile for Children's mission, the travel expenses of Korean volunteers accounted for 29 % of the total direct costs. The labor costs for Vietnamese health providers, including highly trained surgeons and anesthesiologists, accounted for only 1 % of the total mission costs. Therefore, the outreach of services and benefits provided to patients could be expanded if the travel expenses of the international volunteers could be eliminated by relying solely on the Vietnamese staff to perform this work. In addition to this cost saving, the patients' average age at the time of surgery would presumably be decreased. The average age of CL/CP patients operated on through the Smile for Children program was 8.3 years. Although the ideal timing of surgery for CL/CP patients is at a much younger age [36], many Vietnamese patients are not operated on at this age because they lack access to surgical care. Also, because some patients require secondary revision surgery after the primary surgery, ensuring local capacity is necessary for continuous support of the patients even after departure of the international volunteer team.

Most deaths from congenital anomalies, including CL/CP, occur within the first month of life. Many infants in Vietnam with these anomalies die before they have the opportunity to obtain appropriate surgical care. By strengthening the local capacity to provide surgery for patients with congenital abnormalities (including CL/CP), Vietnamese patients can be operated on at an earlier age, thereby saving additional lives and reducing additional disability. Despite the value and cost-effectiveness of international volunteer missions such as those of Smile for Children, strengthening local surgical capacity is the most important long-term strategy for developing a sustainable system for the appropriate care of these children.

However, building local highly specialized surgical capacity for conditions such as CL/CP in developing countries requires a long-term commitment from a supporting organization such as Smile for Children. Collaboration between volunteers from outside the country with in-country health care providers is necessary to achieve this goal.

At the same time, without proper support from local health workers, surgery provided by international organizations would not be as effective. Thus, to provide a strong springboard for improving local capacity, a strong partnership between local health providers and international technical support is critical. Building local capacity through partnerships expands the cost-effectiveness of surgical missions, such as those by Smile for Children, beyond what we have been able to measure in our study. Thus, in reality, the long-term cost-effectiveness of the collaboration goes far beyond the immediate impact on the patients who benefit at the time of the mission trip.

In the developing world, there is a great need to improve access to essential and life-saving services. Only 4 % of the world's surgical procedures are performed in countries with a per capita health expenditure of <$100, even though these countries constitute 35 % of the world's population [37]. Although some international NGOs provide specialized clinical services, such as CL/CP surgery, most patients in the developing world still confront insurmountable barriers to access such care. Paying for the costs of travel, food, and hospitalization is a significant challenge for poor patients, especially those living in isolated rural areas. Therefore, international health service providers need to pay more attention to reducing these costs for poor patients and their families to ensure accessibility.

The problems associated with patients having access to health care cannot be solved solely by international surgical mission teams. A long-term strategic collaboration with in-country providers is one approach to improving accessibility for certain specific health services, such as CL/CP repair.

Limitations of the study

One limitation of our study is that the cost data used in this study did not include additional lifelong costs for speech therapy and other rehabilitation expenses. Although we considered the residual disability weight after primary repair to be 0.016 for CL and 0.015 for CP after primary repair, the residual disability could be more significant in countries such as Vietnam, where access to speech therapy and other types of rehabilitative care is not available. Because such rehabilitation care is limited in Vietnam, omitting this cost seems appropriate. In addition, our study assumed that the complication rate from the surgery operated by Smile for Children was zero. No fatal complications have been reported among CL/CP patients treated over the entire 15 year-period, but information about non-fatal complications may not be complete.

Another limitation is that the analysis does not consider the costs related to utilization of the local hospital facility. It is arguable that ignoring this cost inappropriately reduces the estimate of the cost-effectiveness. However, we think that donations from the mission team to the local hospital are enough to offset the facility-related cost. After each mission, more than 20 % of surgical supplies and medicines brought to the mission site are unused during the mission and then donated after completing the mission. In case of a supply shortage, the team buys the required items on site or pays for the cost of supplies used that were already in the facility for other purposes. Therefore, the total cost for hospital facilities is including in our analysis by embedding it and assuming it is equal to the value of the donation from the mission group.

An additional possible limitation of the study comes from the assumption that the costs for CL/CP patients and non-CL/CP patients treated by the mission team are the same. According to the mission team surgeons, CL/CP cases can consume more supplies than other types of cases the mission treats, so the cost per patient might be slightly underestimated, but the difference is not likely to be significant. Furthermore, medical supplies account for only one-third of total costs. The only fixed cost (which is independent of the number of cases treated) is the administrative cost, which accounts for only 5 % of the total costs. If fewer patients were treated by the mission team (because they treated only CL/CP patients, for instance), all the other costs would have gone down proportionately because fewer Koreans and Vietnamese would have participated as members of the mission team, fewer supplies would have been used, and so forth.

Another limitation in this study is the lack of quality assessment of the services provided by Smile for Children. This is a widespread issue. Although short-term volunteer surgical missions extend the reach of health services in a number of developing countries, evaluations of the quality of such services have not been reported. Any assessment of the impact of the program—and hence the assessment of its cost-effectiveness—is not complete without proper assessment of the quality of services provided.

The final limitation of our study is the intrinsic problem of DALY calculations. Although disability weights are required to quantify the loss of healthy life, several critics have questioned the approach of assigning disability weights [38]. Critics argue that the disability weight does not accurately assess the health outcome in diverse environments. Recently, to overcome this limitation, input from a broad cross section of cultural, environmental, and demographic circumstances have been acquired [31]. However, further studies are required in diverse settings for more accurate estimation of disability weights for CL/CP.

Conclusions

In resource-constrained settings, surgical interventions are often regarded as cost-ineffective. Furthermore, there is an additional criticism about whether volunteer international surgical mission work in particular—that it is neither justifiable nor sustainable. The findings from this study contradict these perceptions. The cost-effectiveness of CL/CP surgery provided by volunteer international surgical mission teams appears to be comparable to that of many standard public health interventions being carried out in developing countries. In addition, strategic collaboration with local health systems and long-term educational efforts can reduce costs and provide long-term benefits by building local capacity. The ultimate goal is to build local capacity to provide proper surgical care for CL/CP patients. However, substantial funding, time, and effort are required to develop this capacity in developing nations when there is no proper support system already in place. In this context, collaboration with international NGOs can contribute to covering unmet local demand for surgical services in the short-term while at the same time enabling long-term partnerships that focus on the training and support necessary to develop the local capacity to ensure sustainable access to surgical care [39]. Thus, based on our findings, international volunteer surgery for CL/CP can be both a justifiable and a cost-effective intervention.

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