The Clinical and Economic Impact of a Sustained Program in Global Plastic Surgery: Valuing Cleft Care in Resource-Poor Settings

Christopher D. Hughes, M.D., M.P.H.
Alan Babigian, M.D.
Susan McCormack, M.A., C.C.C./S.L.P.
Blake C. Alkire, M.D., M.P.H.
Anselm Wong, M.D.
Stephen A. Pap, M.D.
Jeffrey R. Vincent, M.S., Ph.D.
John G. Meara, M.D., D.M.D., M.B.A.
Charles Castiglione, M.D.
Richard Silverman, M.D.

Farmington and Hartford, Conn.; Boston, Cambridge, Brighton, and Worcester, Mass.; Philadelphia, Pa.; and Durham, N.C.

Background: The development of surgery in low- and middle-income countries has been limited by a belief that it is too expensive to be sustainable. However, subspecialist surgical care can provide substantial clinical and economic benefits in low-resource settings. The goal of this study is to describe the clinical and economic impact of recurrent short-term plastic surgical trips in low- and middle-income countries.

Methods: The authors conducted a retrospective review of clinic and operative logbooks from Hands Across the World's surgical experience in Ecuador. The authors calculated the disability-adjusted life-years averted to estimate the clinical impact of cleft repair and then calculated the economic impact of surgical intervention for cleft disease.

Results: One thousand one hundred forty-two reconstructive surgical cases were performed over 15 years. Surgery was most commonly performed for scar contractures [449 cases (39.3 percent)], of which burn scars comprised a substantial amount [215 cases (18.8 percent)]. There were 40 postoperative complications within 7 days of operation (3.5 percent), and partial wound dehiscence was the most common complication [16 of 40 (40 percent)]. Cleft disorders constituted 277 cases (24.3 percent), and 102 cases were primary cleft lip and/or palate cases. Between 396 and 1042 total disability-adjusted life-years were averted through surgery for these 102 cases of primary cleft repair. This translates to an economic benefit between $4.7 million (human capital approach) and $27.5 million (value of a statistical life approach).

Conclusions: Plastic surgical disease is a significant source of morbidity for patients in resource-limited regions. Dedicated programs that provide essential reconstructive surgery can produce substantial clinical and economic benefits to host countries. (*Plast. Reconstr. Surg.* 130: 87e, 2012.)

The public health importance of essential surgical services is gaining recognition within the global health community.[1–4] Death and disability rates associated with surgically treatable conditions are at least 11 percent worldwide, and access to and provision of basic life-saving surgery are distributed unequally around the world to favor those in higher income countries.[5,6]

From the Departments of Surgery and Orthopedic Surgery, University of Connecticut School of Medicine; the Department of Plastic and Oral Surgery, Children's Hospital Boston, Harvard Medical School; the Program in Global Surgery and Social Change, Department of Global Health and Social Medicine, Harvard Medical School; the Division of Plastic and Reconstructive Surgery, Hartford Hospital and Connecticut Children's Medical Center; The Children's Hospital of Philadelphia; the Massachusetts Eye and Ear Infirmary; the Division of Plastic and Reconstructive Surgery, Mt. Auburn Hospital, Harvard Medical School; the Nicholas School of the Environment and Sanford School of Public Policy, Duke University; the Division of Plastic and Reconstructive Surgery, St. Elizabeth's Medical Center; and the Division of Plastic and Reconstructive Surgery, University of Massachusetts School of Medicine.

Received for publication December 20, 2011; accepted January 20, 2012.
Presented at the 92nd Annual Meeting of the New England Surgical Society, in Bretton Woods, New Hampshire, September 23 through 25, 2011, and at the Annual Meeting of the Connecticut Chapter of the American College of Surgeons, in Farmington, Connecticut, November 4, 2011.
Copyright ©2012 by the American Society of Plastic Surgeons
DOI: 10.1097/PRS.0b013e318254b2a2

Disclosure: *The authors have no financial interest to declare in relation to the content of this article.*

Copyright © American Society of Plastic Surgeons. Unauthorized reproduction of this article is prohibited.

Historically, the development of general surgery and surgical subspecialist care in low- and middle-income countries has been limited by a belief that surgery is too expensive and resource-intensive to be conducted in a sustainable manner. However, an increasing number of data are beginning to contradict this long-held view; in fact, well-executed surgical programs can provide cost-effective and economically beneficial care even in limited-resource settings.[7–9] Often, the cost per disability-adjusted life-year averted of surgical services in low- and middle-income countries is comparable or even superior to that of nonsurgical interventions such as vaccines and oral rehydration programs. Plastic and reconstructive surgery has an extensive history in low- and middle-income countries[10] and can contribute significantly to the public health and economic infrastructure in developing nations.[11–13] Recent work has demonstrated that it can also be cost-effective and economically beneficial in resource-poor settings.[14–16]

The short-term "mission" model is common among plastic surgeons practicing in low- and middle-income countries, wherein care is delivered by varying surgical teams in 1- or 2-week intervals. Some have advocated against this platform, citing the potential for increasing the resource strain on local health care infrastructures and unfavorable benefit-to-cost profiles.[17,18] Although these arguments are important, the nature of the U.S. health care system necessitates that most surgeons will continue to participate in the short-term model. Within this context, the challenge is therefore to improve the clinical impact and cost-effectiveness of the short-term model as a vital component of larger scale health system development.

Hands Across the World is a Massachusetts-based nonprofit organization that has been providing reconstructive surgical services in rural Ecuador over the past 20 years.[19] The purpose of this study is to examine the impact of recurrent, short-term surgical care by modeling the clinical and economic effect of surgery for cleft lip–cleft palate as part of Hands Across the World's sustained plastic surgery program. Based on previously published modeling strategies, we hypothesize that the cumulative effect of a dedicated plastic surgical program yields substantial benefits for the host country.

METHODS

We conducted a retrospective review of a clinical database for all consecutive reconstructive surgical cases performed by Hands Across the World teams in Ecuador from 1996 to 2011. This study was approved by the Institutional Review Board at Children's Hospital Boston. Data included information regarding patient age, sex, operative diagnosis and procedure, surgeon, and 1-week postoperative complications. All patients were treated at various district and regional hospital facilities in rural Ecuador.

Hands Across the World is a nonprofit organization dedicated to providing reconstructive surgical care for congenital defects, burns, and other ailments in resource-poor settings around the world. Since 2004, they have partnered with the Division of Plastic Surgery at the University of Massachusetts, Worcester. The partnership has coordinated short-term, multidisciplinary surgical teams in Ecuador over the past 20 years, and we have maintained an accurate database for our cases over the past 15 years, allowing for this review.

Clinical Impact and Disability-Adjusted Life-Years

The disability-adjusted life-year is a measure of health outcomes attributable to a specific disease process. It incorporates not only the premature mortality associated with a disease but also the potential for disability. One disability-adjusted life-year is equivalent to 1 year of healthy life lost because of a disease. The potential health benefits of surgical intervention can therefore be described in terms of the disability-adjusted life-years averted by that particular treatment modality. Disability-adjusted life-years for cleft lip–cleft palate can be conceptualized by the following equation:

$$\text{DALYs (cleft)} = \text{YLL} + \text{YLD}$$

We can reasonably assume that cleft disease results in the number of years of life lost to the disease = 0. Therefore, the total disability-adjusted life-years attributable to cleft disease are determined by the following equation:

$$\text{DALYs (cleft)} = \text{YLD}$$

The derivation of disability-adjusted life-years averted secondary to surgical intervention for cleft disease has been published in detail elsewhere.[16] Briefly, we used disability weights for cleft disease from the 2004 global burden of disease study to describe the benefit of surgical intervention for patients treated by Hands Across the World in Ecuador from 1996 to 2011.[20]

A disability weight is a weighting factor that reflects the severity of a disease on a scale from 0 (perfect health) to 1 (death). Because established disability weights are available for cleft lip–cleft

Copyright © American Society of Plastic Surgeons. Unauthorized reproduction of this article is prohibited.

palate, we used these as proxies to assess the cumulative impact of a long-term program in global plastic surgery. Surgery for cleft lip–cleft palate does not reduce disease-associated morbidity to 0, so we calculated and subtracted the treated disease weight from the untreated disease weight for each patient. These numbers (0.082 for cleft lip and 0.216 for cleft palate) represent the net reduction in disability attributable to cleft lip–cleft palate after surgery.

In addition, disability-adjusted life-years can be calculated with and without the concept of age-weighting, which adjusts disability-adjusted life-years so that some years of life are valued more than others. They can also be calculated with and without discounting, which results in a disability-adjusted life-year averted today being worth more than a disability-adjusted life-year averted tomorrow. The predominant argument for discounting future disability-adjusted life-years in the global burden of disease literature is that not doing so would suggest that funding should always be directed to investment in future generations, when technological advances would result in an ever-decreasing cost per disability-adjusted life-year averted[20]; another argument, perhaps more compelling, is that discounting is implied by the way individuals actually behave in making tradeoffs between the present and the future. Each of these concepts is controversial and can lead to more conservative or more generous estimates of health improvement secondary to an intervention.[21,22] Therefore, we calculated disability-adjusted life-years averted from cleft care using three models: (1) disability-adjusted life-years without discounting and without age-weighting, (2) disability-adjusted life-years with discounting and age-weighting using the standard global burden of disease parameters, and (3) disability-adjusted life-years with discounting using the standard global burden of disease discount rate and age-weighting that results in the value of a disability-adjusted life-year peaking at two-thirds of life-expectancy in Ecuador.

Economic Impact

Converting the disability-adjusted life-years averted by surgical intervention into an estimate of economic benefit has been described previously.[14,16] One method to determine the worth of an averted disability-adjusted life-year is termed the "human capital approach," which contextualizes an individual's disease in relation to their potential economic contribution to society: improved health is valued insofar as it enables people to contribute more to their country's economic output.[23] Disability (or death) caused by disease will necessarily decrease their contribution to their national economy. A rough estimate of an average individual's contribution to society is the gross national income per capita. Therefore, we estimated the economic impact of treating cleft disease in the setting of Hands Across the World's trips by multiplying the specific disability-adjusted life-years averted through cleft lip–cleft palate treatment by the 2003 Ecuadorian gross national income per capita (in U.S. dollars). We used 2003 because it is the midpoint of the sample period. (Because disability-adjusted life-years refer to lifetime impacts, not just to impacts in the year of surgery, using a common value of an averted disability-adjusted life-year across all surgical years is justified: the 15-year sample period is short compared with Ecuadorian life expectancy, and so values specific to each surgical year would be excessively precise.)

All information regarding gross national income per capita was collected from the World Bank database,[24] and we used the purchasing power parity variant of gross national income per capita according to an authoritative review of valuing reductions in fatality.[25] It should be noted that the use of gross national income per capita probably results in an overstatement of the value of an averted disability-adjusted life-year, as patients were in rural areas where income tends to be lower than the national average. In contrast, holding the value constant at its 2003 value could understate the value, as it ignores the possibility that gross national income per capita could grow in the future as Ecuador develops.

An alternative approach to valuing the economic impact of disease (and disease treatment) is known as the value of a statistical life, which attempts to measure value from the standpoint of an individual facing a health risk. Value of a statistical life reflects the maximum amount an individual would be willing to spend to reduce, by a small amount, his or her risk of dying during a particular period. It is used by government agencies around the world for programmatic benefit-to-cost analyses and has been introduced previously as a way of evaluating the potential economic impact of disease in resource-poor settings.[14,16]

Economists have developed a method for transferring value of a statistical life estimates from countries in which studies have been performed (e.g., the United States) to countries in which they have not been performed (e.g., Ecuador). To deter-

Copyright © American Society of Plastic Surgeons. Unauthorized reproduction of this article is prohibited.

mine the value of a statistical life for Ecuador, we applied the following equation[25]:

$$\mathrm{VSL(Ecuador)} =$$

$$\mathrm{VSL(USA)} \times [\mathrm{GNIp.c.(Ecuador)/GNIp.c.(USA)}]^{\mathrm{IE\text{-}VSL}}$$

The value of a statistical life in the United States in 2003 was $7.0 million.[25] Income elasticity of the value of a statistical life is how responsive the value of a statistical life is to the level of income. Estimates of income elasticity of the value of a statistical life range from 0.55 to 1.5,[26] with increasing evidence suggesting that larger estimates are more appropriate when income is lower. We provide estimates for both 1.0 and 1.5, as Ecuador is a middle-income developing country and Hands Across the World's patients tend have lower incomes than the Ecuadorian national average.

To use value of a statistical life to describe the benefit of averting 1 disability-adjusted life-year and its effect over the course of a patient's life, it needs to be converted into its annualized equivalent, termed the value of a statistical life-year, and contextualized to a specific country's life expectancy. Recent studies suggest that the value of a statistical life-year peaks at two-thirds of life expectancy.[27] To be consistent with these data, we calculated disability-adjusted life-years that were discounted by the global burden of disease discount factor and age-weighted such that the age-specific value of a disability-adjusted life-year (i.e., value of a statistical life-year) peaks at two-thirds of life expectancy. We calculated the value of a statistical life for Ecuador in 2003 using the formula above, derived age-specific value of statistical life-years from it, and multiplied the latter by the corresponding number of lifetime disability-adjusted life-years averted as a result of operations performed during that year's surgical trip. All monetary valuations for the human capital approach and value of a statistical life approach were adjusted to 2011 U.S. dollars using the gross domestic product deflator to reflect the influence of inflation over the years from 2003 to 2011.[28] All statistic analyses were performed using customized Excel (Microsoft Corp., Redmond, Wash.) spreadsheets and SPSS version 19.0 (SPSS, Inc., Chicago, Ill.).

RESULTS

Clinical Impact

Patient demographic and clinical information is listed in Table 1. There were 1142 total reconstructive surgical operations performed from 1996 to 2011. Forty-five percent of the patients were female, and the average age was 18.9 years (range, 0.1 to 74.0 years). Two hundred seventy-seven patients (24.3 percent) presented with cleft disease, including 17 lip only, 38 palate only, and 123 lip and palate. Scar contractures constituted the majority of presenting diagnoses [449 cases (39.3 percent)], of which burn scars constituted a substantial amount [215 cases (18.8 percent of the total cases)]. Hand-related conditions, including tendon contractures, burns, polydactyly, and syndactyly, constituted 10.8 percent of the total cases, and Hands Across the World surgeons treated a variety of congenital ear anomalies as well (8.7 percent of total cases). Postoperative data were available for 1122 patients (98.2 percent). Of those with postoperative data, 1089 patients (97.1 percent) were seen and evaluated within 7 days for postoperative follow-up. There were 40 postoperative complications (3.5 percent), and partial wound dehiscence was the most common [16 of 40 (40 percent)].

Table 1. Patient Demographics*

Characteristic	Value (%)
No. of patients	1142
Age, yr	
Mean ± SD	18.9 ± 14.9
Range	0.1–74.0
No. of pediatric patients (≤18 yr)	662
No. of adult patients (>18 yr)	480
Female sex	513 (45.0)
Presenting diagnosis	
Cleft	277 (24.3)
Lip and palate	123
Palate only	38
Lip only	17
Palatal fistula	31
VPI	23
Whistle deformity	6
Scar	449 (39.3)
Burn contracture	215
Keloid	20
Hypertrophic	9
Miscellaneous	208
Hand	123 (10.8)
Tendon injury/contracture	36
Burns	17
Polydactyly	12
Syndactyly	11
Miscellaneous	58
Congenital ear anomaly	99 (8.7)
Microtia	57
Preauricular tags	19
Miscellaneous	25
Vascular anomaly	12 (1.1)
Postoperative complications	40 (3.5)
Partial wound dehiscence	16
Hematoma	9
Partial necrosis	6

VPI, velopharyngeal insufficiency.
*Categories may not sum because of multiple diagnoses.

Copyright © American Society of Plastic Surgeons. Unauthorized reproduction of this article is prohibited.

The clinical impact of cleft lip–cleft palate treatment by Hands Across the World in Ecuador from 1996 to 2011 is depicted in Table 2. There were 48 cases performed for repair of primary cleft lip and 54 cases performed for repair of primary cleft palate. Surgery for cleft lip–cleft palate averted 1042 disability-adjusted life-years (without discounting or age-weighting) (0, 0, 0), 544 disability-adjusted life-years (with 3 percent discounting and global burden of disease age-weighting) (3, 1, 0.04), or 396 disability-adjusted life-years (with discounting at 3 percent and age-weighting with an Ecuador-specific age-weight linked to life expectancy) (3, 1, CSβ), depending on the chosen methodology.

Economic Impact

Using a human capital approach, the disability-adjusted life-years averted through Hands Across the World's cleft lip–cleft palate treatment translates into an economic benefit of $4,738,503 (in 2011 U.S. dollars) (Table 3). We assumed a value of a statistical life in the United States of $7.0 million in 2003 based on previous studies.[25] After accounting for inflation between 2003 and 2011, discounting, and age-weighting with Ecuador-specific age-weighting parameters, we calculated the value of a statistical life–based economic impact to be between $10,415,778 and $27,461,154, depending on the chosen income elasticity when calculating the value of a statistical life. Hands Across the World conducted 16 surgical trips to rural Ecuador from 1996 to 2011. Averaged over the course of the program, the resulting economic impact of surgery for cleft lip–cleft palate is between $296,156 (human capital) and $1,716,322 (value of a statistical life) per surgical week.

Table 2. Total Disability-Adjusted Life-Years Averted through Treatment of Primary Cleft Disease by Hands Across the World from 1996 to 2011

	Total Cases	Total DALYs Averted*		
		(3, 1, 0.04)	(0, 0, 0)	(3, 1, CSβ)
Cleft lip	48	134	263	97
Cleft palate	54	410	779	299
Total	102	544	1042	396

DALYs, disability-adjusted life-years.
*The nomenclature disability-adjusted life-years (r, K, β) is used to signify whether disability-adjusted life-years have been adjusted for discounting or age-weighting, where r is the discount rate, K is the modulation of age-weighting, and β is the age-weighting parameter. Disability-adjusted life-years (0, 0, 0) denotes no discounting or age-weighting; disability-adjusted life-years (3, 1, 0.04) denotes a 3 percent discount rate, with age-weighting at 4 percent; and disability-adjusted life-years (3, 1, CSβ) denotes disability-adjusted life-years calculated with a 3 percent discount rate, with age-weighting at an Ecuador-specific rate linked to life expectancy.

Table 3. Economic Benefit of Treatment of Cleft Disease by Hands Across the World from 1996 to 2011

	Human Capital (3, 1, 0.04)*	VSL	
		(IE-VSL = 1.0)	(IE-VSL = 1.5)
Cleft lip	$720,098	$4,190,347	$1,565,958
Cleft palate	$2,198,480	$12,976,548	$4,849,414
Total			
2003 U.S. dollars	$2,918,578	$17,166,895	$6,415,372
2011 U.S. dollars	$4,738,503	$27,461,154	$10,415,778

VSL, value of a statistical life; IE-VSL, income elasticity of value of a statistical life.
*The nomenclature disability-adjusted life-years (r, K, β) is used to signify whether disability-adjusted life-years have been adjusted for discounting or age-weighting, where r is the discount rate, K is the modulation of age-weighting, and β is the age-weighting parameter. Disability-adjusted life-years (3, 1, 0.04) denotes a 3 percent discount rate, with age-weighting at 4 percent.

Using the value of a statistical life approach, treatment for cleft lip resulted in an economic benefit between $52,967 and $141,736 per patient. Treatment of cleft palate resulted in an economic benefit of between $145,803 and $390,153 per patient. Using the human capital approach, treatment for cleft lip and palate resulted in an economic benefit of approximately $24,357 and $66,100 per patient, respectively.

DISCUSSION

This study provides region-specific evidence for the clinical and economic impact of surgery for cleft lip–cleft palate as part of a program of recurring short-term plastic surgical trips in limited-resource settings. Based on previous estimates,[14–16] we hypothesized that a surgical program for cleft care can yield substantial clinical and economic benefits in these environments.

Surgery for primary cleft lip–cleft palate represents roughly 10 percent of Hands Across the World's clinical volume over the past 15 years in Ecuador. However, disability weights are currently unavailable for many other plastic surgical diseases. We therefore used only Hands Across the World's experience with cleft lip–cleft palate for our clinical and economic models.

Hands Across the World's program produced a substantial clinical benefit within its target community. Surgeons performed 1124 plastic surgical cases over 15 years in Ecuador, including reconstructive surgery for burn scar contractures, cleft lip–cleft palate, and a variety of congenital anom-

Copyright © American Society of Plastic Surgeons. Unauthorized reproduction of this article is prohibited.

alies of the face and hand. Clinical follow-up revealed an overall complication rate of 3.5 percent.

There were 102 cases of primary cleft lip and/or palate; surgery for these disorders averted between 396 and 1042 disability-adjusted life-years from 1996 to 2011. Because the 2004 global burden of disease does not assign disability weights for secondary clefting disorders, we included only primary cases in the analysis. Economic modeling to translate disability-adjusted life-years averted from cleft lip–cleft palate surgery into 2011 U.S. dollars revealed a significant economic impact as well: between $4.7 million and $27.5 million, depending on the modeling approach. Assuming roughly equal production over each of the 16 short-term surgical trips, the program resulted in economic benefits between $296,156 (human capital) and $1,716,322 (value of a statistical life) per surgical week.

Any approach to economic modeling carries with it a set of implicit assumptions. The human capital approach typically represents a conservative estimate of an intervention's impact primarily because it assigns value based solely on contributions to the economy. It uses gross national income per capita as a proxy for personal economic productivity and assumes that the value of improved health varies in relation to the value of that person's labor.[23] It does not account for personal valuations of risk reduction. By comparison, the value of a statistical life approach typically represents the higher end of economic modeling estimates. Value of a statistical life estimates are based on human behavior and thus likely provide more accurate assessments of the personal value assigned to health risk reductions.[16,29] The value of a statistical life has been used by governmental agencies around the world in benefit-to-cost analyses and has been applied to evaluate public health interventions at the community level.[30] We believe that the economic impact of investment in surgical programs for cleft lip–cleft palate in limited-resource settings likely lies nearer the value of a statistical life estimate precisely because it accounts for personal valuations of health risk reduction.

Our results compare favorably with other studies that have attempted to estimate the beneficial impact of cleft lip–cleft palate treatment in terms of U.S. dollars. A review of Operation Smile missions in 2008 identified up to 3099 disability-adjusted life-years averted through cleft lip–cleft palate treatment, but they did not value the economic impact of their recurrent interventions.[15] Using clinical data for 568 patients treated in 2005 from a permanent Interplast program in Nepal, Corlew determined that the value of a statistical life–based economic impact of cleft lip–cleft palate repair with discounting and age-weighting yielded an estimated $48.2 million in economic benefit. Although our case numbers are smaller and span fewer surgical weeks, we estimated similarly substantial economic impact of cleft lip–cleft palate treatment. In contrast to these previous studies, we constructed our value of a statistical life economic model using a country-specific beta to ensure that both disability-adjusted life-year and value of a statistical life-year value peaks at two-thirds of a country's life expectancy.[27] Thus, our estimates are able to provide a more region-specific and internally consistent estimate of the total economic impact of surgical intervention within that community.

Short-term surgical missions constitute an example of vertical health interventions in low- and middle-income countries. Vertical programs typically focus on a specific disease or specialized treatment modality, whereas horizontal programs tend to be more systems focused and encompass a broader range of health services. Recent trends in global health funding and development have begun to favor horizontal health programs within developing nations.[31] Despite historical success, increasing concerns about future scalability and the resource demands of vertical programs have created a shift within the global health community toward building sustainable health systems. Short-term surgical missions have been criticized for similar reasons, namely, a lack of adequate follow-up and inefficient costing structures.[17,18] However, our data suggest that, in the proper context, well-run short-term surgical programs for cleft lip–cleft palate can be both clinically and economically beneficial to host regions. Although these vertically oriented models may not be ultimate solutions to building sustainable health systems in low- and middle-income countries, they continue to serve a vital and beneficial role in delivering surgical care to the world's underserved communities.

Our study has several important limitations to consider. Although it provides unique, evidence-based estimates for the economic benefits of cleft lip–cleft palate surgery in the setting of short-term surgical trips, our clinical data represent a 15-year history with one organization in one country. Estimates of impact may therefore not be generalizable to a broader global health context. However, our results compare favorably with other estimates of the benefit of treating cleft lip–cleft

Copyright © American Society of Plastic Surgeons. Unauthorized reproduction of this article is prohibited.

palate in similar settings.[14,15] In addition, cleft care represents only approximately 10 percent of the total surgical care provided by Hands Across the World. Because the most recent 2004 global burden of disease does not provide disability weights for other, more commonly encountered diagnoses in this context, we used only cleft lip–cleft palate as a proxy for the total impact of Hands Across the World's surgical program. This figure therefore underestimates the program's total clinical and economic impact.

A complete costing profile was unavailable for our study and thus our estimates represent gross benefits, not net benefits. Future studies will continue to investigate the economic impact of plastic surgery in low- and middle-income countries by incorporating both financial and economic costs associated with global plastic surgery programs. Accurate and reliable cost estimates for cleft centers and short-term programs will provide valuable information for benefit-to-cost analyses to better determine the scale of investment benefits and to contextualize plastic surgery within other global health initiatives. Other programs in global surgery have begun to show advantageous benefit-to-cost ratios,[15] especially when compared with certain other medical interventions.

CONCLUSIONS

Dedicated short-term plastic surgical programs for cleft lip–cleft palate can have a substantial clinical and economic impact in resource-poor settings. Cleft lip–cleft palate represents a minority of total reconstructive surgical care in low- and middle-income countries, and the full clinical and economic impact of plastic surgical programs is likely much greater. Likewise, diseases amenable to treatment with plastic surgery represent only a fraction of the burden of surgical disease in developing nations. Investment in horizontal surgical programs that address the spectrum of needed surgical care could yield even greater impacts and returns on investment.

Christopher D. Hughes, M.D., M.P.H.
Department of Plastic and Oral Surgery
Children's Hospital Boston
300 Longwood Avenue, Enders 1
Boston, Mass. 02115
chughes414@gmail.com

ACKNOWLEDGMENTS

The authors acknowledge the Pyrtek Fund at Hartford Hospital and the University of Connecticut Department of Surgery for providing educational support for this project. In addition, each of the team members of Hands Across the World's multiple surgical trips over the past 15 years, too numerous to mention individually here, deserves special recognition and gratitude.

REFERENCES

1. Farmer PE, Kim JY. Surgery and global health: A view from beyond the OR. *World J Surg.* 2008;32:533–536.
2. McQueen KA, Ozgediz D, Riviello R, et al. Essential surgery: Integral to the right to health. *Health Hum Rights* 2010;12:137–152.
3. Leow JJ, Kingham TP, Casey KM, Kushner AL. Global surgery: Thoughts on an emerging surgical subspecialty for students and residents. *J Surg Educ.* 2010;67:143–148.
4. McIntyre T, Zenilman ME. Globalization of surgery: Let's get serious. *Arch Surg.* 2010;145:715–716.
5. Debas H, Gosselin R, McCord C, Thind A. Surgery. In: Jamison DT, ed. *Disease Control Priorities in Developing Countries.* 2nd ed. New York: Oxford University Press; 2006:1245–1260.
6. Weiser TG, Regenbogen SE, Thompson KD, et al. An estimation of the global volume of surgery: A modelling strategy based on available data. *Lancet* 2008;372:139–144.
7. McCord C, Chowdhury Q. A cost effective small hospital in Bangladesh: What it can mean for emergency obstetric care. *Int J Gynaecol Obstet.* 2003;81:83–92.
8. Gosselin RA, Thind A, Bellardinelli A. Cost/DALY averted in a small hospital in Sierra Leone: What is the relative contribution of different services? *World J Surg.* 2006;30:505–511.
9. Gosselin RA, Moldonado A, Elder G. Comparative cost-effectiveness analysis at two MSF surgical trauma centers. *World J Surg.* 2010;34:415–419.
10. Hughes CD, Alkire BC, Martin C, Semer N, Meara JG. American plastic surgery and global health: A brief history. *Ann Plast Surg.* 2012;68:222–225.
11. Semer NB, Sullivan SR, Meara JG. Plastic surgery and global health: How plastic surgery impacts the global burden of surgical disease. *J Plast Reconstr Aesthet Surg.* 2010;63:1244–1248.
12. Campbell A, Sherman R, Magee WP. The role of humanitarian missions in modern surgical training. *Plast Reconstr Surg.* 2010;126:295–302.
13. Corlew DS. Perspectives on plastic surgery and global health. *Ann Plast Surg.* 2009;62:473–477.
14. Corlew DS. Estimation of impact of surgical disease through economic modeling of cleft lip and palate care. *World J Surg.* 2010;34:391–396.
15. Magee WP Jr, Vander Burg R, Hatcher KW. Cleft lip and palate as a cost-effective health care treatment in the developing world. *World J Surg.* 2010;34:420–427.
16. Alkire B, Hughes CD, Nash K, Vincent JR, Meara JG. Potential economic benefit of cleft lip and palate repair in sub-Saharan Africa. *World J Surg.* 2011;35:1194–1201.
17. Dupuis CC. Humanitarian missions in the third world: A polite dissent. *Plast Reconstr Surg.* 2004;113:433–435.
18. Wolfberg AJ. Volunteering overseas: Lessons from surgical brigades. *N Engl J Med.* 2006;354:443–445.
19. Hands Across the World. Available at: http://www.handsacrossworld.com/. Accessed July 11, 2011.
20. Mathers C, Fat DM, Boerma JT, et al. *The Global Burden of Disease: 2004 Update.* Geneva: World Health Organization; 2008.
21. Fox-Rushby JA, Hanson K. Calculating and presenting disability adjusted life years (DALYs) in cost-effectiveness analysis. *Health Policy Plan.* 2001;16:326–331.

Copyright © American Society of Plastic Surgeons. Unauthorized reproduction of this article is prohibited.

22. Murray CJL, Lopez AD; Harvard School of Public Health. *The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability from Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020*. Cambridge, Mass: Harvard School of Public Heath on behalf of the World Health Organization and the World Bank; Distributed by Harvard University Press; 1996.
23. World Health Organization Commission on Macroeconomics and Health. *Macroeconomics and Health: Investing in Health for Economic Development. Geneva*: World Health Organization; 2001.
24. World Bank. The World Bank: Open data. Available at: http://data.worldbank.org/. Accessed July 11, 2011.
25. Viscusi WK, Aldy JE. The value of a statistical life: A critical review of market estimates throughout the world. *J Risk Uncertain.* 2003;27:5–76.
26. Hammitt JK, Robinson LA. The income elasticity of the value per statistical life: Transferring estimates between high and low income populations. *J Benefit-Cost Analysis* 2011;2:1–27.
27. Aldy JE, Viscusi WK. Adjusting the value of a statistical life for age and cohort effects. *Rev Econ Stat.* 2008:90;573–581.
28. Bureau of Labor Statistics. Available at: http://www.bls.gov/data. Accessed July 21, 2011.
29. Hammitt JK. Valuing changes in mortality risk: Lives saved versus life years saved. *Rev Environ Econ Pol.* 2007;1:228–240.
30. Asian Development Bank. Arrive alive: ASEAN commits to cutting road deaths. In: *ASEAN Regional Road Safety Strategy and Action Plan (2005–2010)*. Metro Manila: Asian Development Bank; 2005.
31. Bärnighausen T, Bloom DE, Humair S. Going horizontal: Shifts in funding of global health interventions. *N Engl J Med.* 2011;364:2181–2183.

Copyright © American Society of Plastic Surgeons. Unauthorized reproduction of this article is prohibited.