World J Surg (2011) 35:1194–1201
DOI 10.1007/s00268-011-1055-1

World Journal of Surgery

Potential Economic Benefit of Cleft Lip and Palate Repair in Sub-Saharan Africa

Blake Alkire · Christopher D. Hughes · Katherine Nash · Jeffrey R. Vincent · John G. Meara

Published online: 23 March 2011

Abstract

Background Acceptance of basic surgical care as an essential element of any properly functioning health system is growing. To justify investment in surgical interventions, donors require estimates of the economic benefit of treating surgical disease. The present study aimed to establish a methodology for valuing the potential economic benefit of surgical intervention using cleft lip and palate (CLP) in sub-Saharan Africa (SSA) as a model.

Methods Economic modeling of cleft lip and cleft palate (CLP) in SSA was performed with retrospective demographic and economic data from 2008. The total number of Disability-Adjusted Life-Years (DALYs) secondary to CLP in 2008 was calculated from accepted clefting incidence rates and disability weights taken from the Global Burden of Disease Project. DALYs were then converted to monetary terms ($US), using both a human capital approach and Value of a Statistical Life (VSL) approach.

Results With the human capital approach, the potential economic benefit if all incident cases of CLP in SSA in 2008 were repaired at birth ranged from $252 million to $441 million. With VSL, the potential economic benefit of the same CLP repair would range from $5.4 billion to $9.7 billion.

Conclusions Cleft lip and cleft palate can have a substantial impact on the economic health of countries in the developing world. Further studies should be directed at quantifying the economic benefit of surgical interventions and quantifying their costs with an economically sound approach.

B. Alkire · C. D. Hughes · K. Nash · J. G. Meara (✉)
Department of Plastic and Oral Surgery, Children's Hospital Boston, 300 Longwood Avenue, Boston, MA 02115, USA
e-mail: john.meara@childrens.harvard.edu

B. Alkire · C. D. Hughes · J. G. Meara
Department of Global Health and Social Medicine, Program in Global Surgery and Social Change, Harvard Medical School, 641 Huntington Avenue, Boston, MA 02115, USA

J. R. Vincent
Nicholas School of the Environment and Sanford School of Public Policy, Duke University, Durham, NC 27708, USA

Introduction

Surgery is increasingly being recognized as a crucial component and partner in global health efforts to alleviate suffering in developing countries. Deemed "the neglected step-child of global health," surgical disease, as suggested by the recent literature, accounts for up to 11% of global Disability-Adjusted Life-Years (DALYs) [1, 2]. As the United Nations millennium development goals (MDGs) deadline approaches in 2015, an increasing consensus advocates that access to surgery is especially crucial for achieving MDGs goals 4 and 5, which call for decreasing child mortality and improving maternal health, respectively [3, 4]. Furthermore, the formation of the World Health Organization (WHO) Global Initiative in Emergency and Essential Surgical Care and the Bellagio Surgical conferences have provided a platform from which the importance of surgical care delivery in decreasing global morbidity and mortality has been highlighted [5, 6].

The relatively recent acknowledgement of surgery as an essential component of health systems begs the question of why the global health community has historically been reticent to consider access to essential surgical care in developing countries as a priority. The explanation likely lies within the traditional discourse in the global health community: (1) an emphasis on infectious disease and (2) a lack of surgeon input resulted in a non-evidence-based, but intuitively appealing view of surgical intervention as a luxury [1]. Further conceptual arguments against a broader role for global surgery have traditionally centered on inadequate cost-effectiveness or a low benefit–cost ratio. Recent evidence, however, suggests that delivering surgical care is indeed cost-effective, and even comparable with childhood immunizations [2]. For example, McCord described a cost per DALY averted of $10 for a hospital that dealt largely with emergency obstetrical care, well in line with a measles vaccination's cost of $30 per DALY averted [7].

Although surgery has not been traditionally included in formal global health discussions, plastic surgeons have nonetheless taken the lead in addressing plastic surgical disease through organizations such as Interplast and Operation Smile. These organizations have demonstrated that in light of the broad social and functional disabilities that accompany cleft lip and palate, these conditions can be repaired for a relatively cheap financial cost of $250 [8]. Magee et al. [9] and Corlew [10] have examined the cost-effectiveness of cleft lip and palate repair at the hospital level in Nepal and other developing countries, and determined that the cost per DALY averted is indeed in line with other disease processes commonly addressed by the global health community.

Unfortunately, the literature on the potential economic benefit of surgical intervention remains underdeveloped, and there is little information about the total economic impact of untreated surgical disease on specific communities. The present study provides an evaluation of the potential economic benefit of cleft lip and palate repair at the country and region levels using methodology advocated by economists within and outside the field of global health [11].

DALYs, dollars, and surgery

The disability-adjusted life-year debuted in the *1993 World Development Report* [12] as a health metric that attempts not only to measure the premature mortality that results from a disease process, but also to address physical impairment and decreased quality-of-life for the duration of an illness. The DALY is the mirror image of a quality-adjusted life-year (QALY), and both are used to compare health outcomes. Whereas health practitioners wish to increase the number of QALYs in a population, they wish to decrease the number of DALYs—one DALY is equal to one year of healthy life lost. The basic formula for calculating the number of DALYs due to incident disease in a population is:

$$\text{DALYs} = YLD + YLL,$$
$$YLD = I \times D \times DW$$
$$YLL = N \times LD,$$

where YLD is the years lost due to disability, YLL is the years of life lost, N is the total number of deaths due to disease, LD is the life expectancy at age of death, I is the incident cases, D is the duration of illness, and DW is the disability weight (ranges from 0 to 1, with 0 = complete health, 1 = death). The disability weight is obtained by asking groups of experts to consider person trade-offs that make social valuations and preferences explicitly clear. As an example, one could ask, "Would you rather add a healthy year of life to 10 healthy people, or add 2 years of healthy life to 10 patients with blindness?" Using an iterative process, a disability weight is then calculated where complete health is rated as 0, and death is rated as 1 [13].

As a simplified example, let us assume that in the United States, disease X results in the deaths of 2,000 people a year. Furthermore, these 2,000 people all die at age 48. Disease X also results in a decreased quality-of-life for 6 months in 40,000 people a year. The life expectancy in the U.S. is 78, and the disability weight assigned to disease X is 0.75. What is the total number of DALYs due to disease X in one year?

$$YLD = 40,000 \text{ cases} \times 0.5 \text{ years} \times 0.75 = 15,000 \text{ years}$$
$$YLL = 2,000 \text{ deaths} \times (78 - 48) = 60,000 \text{ years}$$
$$\text{DALYs} = 15,000 + 60,000 = 75,000 \text{ DALYs}$$

One could therefore draw the conclusion that if society were to eliminate disease X, it would avert 75,000 DALYs every year.

The calculation of DALYs becomes more complicated when the concepts of age-weighting and discounting are introduced into the equation. Age-weighting adjusts the DALY formula such that life as a young adult is valued more than life in the first and last years of life. The rationale for age-weighting lies in a number of studies indicating that society preferentially values a year of life in a young adult over children and the elderly [14]. Discounting is a standard feature of benefit–cost analysis, where it is used to determine the present value of monetary flows that will be realized in the future; owing to positive interest rates in capital markets, "a dollar today is worth more than a dollar tomorrow." In the case of DALYs, an additional rationale for discounting is known as the "disease eradication and health research paradox":

> not discounting future health would lead to the conclusion that all of society's health resources should be invested in research programs or programs for disease eradication, which produce an infinite stream of

benefits, rather than any programs that improve the health of the current generation [14].

The DALY is a useful tool with which to compare health outcomes, but presented as a concept in isolation, it has little meaning to most audiences. Literature produced by the WHO and others has outlined a basic methodology for translating DALYs to dollars, thus approximating the potential economic benefit of eradicating a specific disease process [11, 15, 16]. Writing for the WHO's Commission on Macroeconomics and Health, Jeff Sachs suggested that multiplying total DALYs by Gross National Income (GNI) per capita begins to approximate the potential economic benefit of eradicating a disease process; however, he notes that this likely undervalues the benefit as it does not take into account social externalities, such as the lost productivity that results from an individual's family members having to care for the individual and pay for medical treatment [11]. In our example above, Sachs's method implies that if disease X were to be eradicated, the economic benefit would be (75,000 DALYs) $\times$ ($48,000/capita) = $3.6 billion dollars a year in the United States. The rationale for using GNI per capita is that disease reduces the overall output of the economy, even after factoring in increased expenditures on medical care. This approach is known as *the human capital approach*, and it assumes that the value of individuals to society is determined by their contributions to the national economy, analogous to the value of a productive machine.

Prompted by the work of Nobel Laureate Thomas Schelling in the late 1960s [17], economists have developed an alternative approach for valuing health risks that is based on the values individuals themselves attach to risk reductions. Central to this approach is the concept of the *value of a statistical life* (VSL), which is the maximum amount someone would be willing to pay to mitigate or avert the risk of dying. For example, an individual who accepts a $5,000 pay cut to switch to a safer job where the fatality risk is 0.001 lower is implicitly revealing that she values the risk reduction at $5 million (=$5,000/0.001). In this example, the VSL is $5 million. As this example indicates, comparing the wages of occupations with different risk profiles is one of the methods economists have developed to estimate VSL [18]. As it also indicates, VSL can be many times larger than an individual's income. This is so because the benefit that individuals attach to an enhanced probability of survival is not constrained by their income. Compared to the production-based logic of GNI per capita, VSL provides a better measure of the benefits of disease reduction from a human welfare standpoint.

Because of its stronger behavioral foundations, VSL is the approach that economists prefer for valuing lives saved by public programs, and it is routinely applied in benefit–cost analyses conducted by government agencies in countries around the world. In the United States, the Department of Transportation uses a VSL of $5.8 million [19], with a mandatory range of $3.2–8.4 million, and the Environmental Protection Agency (EPA) uses a VSL of $7.4 million [20]. In contrast, GNI per capita in the United States was $47,930 in 2008, more than 100 times smaller.

To our knowledge, the Australian government is the only national government that has considered using VSL to value the economic burden of DALYs [16], although the U.S. Department of Transportation calculates nonfatal health risks as a proportion of VSL. To use VSL to value the economic burden of DALYs—or the economic benefit of averted DALYs—it must be converted to its annualized equivalent, the value of a statistical life-year (VSLY). If one treats the VSL as the present value of an annuity, then the VSLY is simply the constant annual payment of an annuity over x years of remaining life [21]. Using the EPA's VSL estimate and a 3% discount rate (and calculating from birth), the corresponding VSLY is $246,000. If all DALYs for disease X were averted, the potential economic benefit using VSLY would be (75,000 DALYs) $\times$ ($246,000) = $18.4 billion dollars per year.

Recent economics research indicates that the VSLY is not constant over an individual's lifetime. Instead, it rises and then falls, thus following the same general shape produced by age-weighting in the DALY formula [22]. A key difference, however, is that economic studies indicate that the peak value occurs during middle age, whereas the reference age-weights in the DALY formula imply a peak value in the mid-20 s for a person with an 80-year life expectancy. When using VSLY to value DALYs, internal consistency dictates that DALYs and VSLY be calculated from the same age-weights. The potential economic benefit of DALYs averted calculated using VSLY can therefore differ from the benefit calculated using GNI per capita for two reasons: (1) the difference between VSLY and GNI per capita, and (2) the difference between age-weights revealed by economic research, which are used to calculate DALYs when VSLY is used as the unit value, and the age-weights recommended in the DALY literature, which are used to calculate DALYs when GNI per capita is used as the unit value.

To demonstrate the potential economic benefit of cleft lip and cleft palate repair, we chose to study a region of the world known to lack general access to adequate surgical care for much of its population: sub-Saharan Africa (SSA).

Materials and methods

Subjects

To quantify the possible economic benefit of cleft lip and palate repair, we used an economic modeling approach

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

based on publicly available retrospective data. The study population includes all estimated cases of cleft lip and palate, based on published cleft incidence rates in the United States [23].

Procedures, terms, and measures

Calculating DALYs for cleft lip and cleft palate

For the purposes of this article, we calculated the number of DALYs attributed to cleft lip and isolated cleft palate in SSA for one year. We assumed that there were no years of life lost due to clefting, and thus $YLL = 0$ and DALYs = *YLD*. Based on available incidence rates for clefting in the U.S. African-American population, we assumed for SSA a cleft lip incidence of 0.6 per 1,000 live births, and a cleft palate incidence of 0.5 cleft palates per 1,000 live births [23]. To calculate the economic benefit of repairing cleft disease, we calculated the number of DALYs that would be averted if all cases were surgically treated at birth. Disability weights (*DW*) were obtained from the 2004 global burden of disease study [24]. Untreated, the *DW* are 0.098 for cleft lip and 0.231 for cleft palate; treatment reduces these to 0.016 and 0.015, respectively. Because cleft lip and cleft palate both have non-zero *DW* when treated, we subtracted the treated *DW* from the untreated *DW* and arrived at 0.216 for cleft palate and 0.082 for cleft lip as the net reductions in disability resulting from treatment. Duration of disease was assumed to be the 2008 life expectancy given for each country by the World Bank [25]. We calculated DALYs with and without discounting and age-weighting, as suggested by Fox-Rushby and Hanson [26], using a 3% discount rate and, when we used GNI per capita as the unit value, with age-weights recommended in the DALY literature [27]. To signify whether DALYs have been adjusted for age and discounted, the symbology DALYs[r, K, β] is used, where r is the discount rate, K is the modulation of age-weighting, and β is the age-weighting parameter. DALYs[0, 0, 0] denotes no discounting and no age-weighting, whereas DALYs[3, 1, 0.04] denotes a 3% discount rate and full age-weighting at $\beta = 0.04$.

The following formula was programed into an Excel spreadsheet by the WHO to determine *YLD*:

where *YLD* is the years lost to disability, *DW* is the disability weight, K is the age-weighting modulation constant (0 = no age-weights, 1 = full age-weights), C is the age-weighting correction constant, r is the discount rate, β is the age-weighting constant (0.04), L is the duration of disease (life-expectancy in country), and a is the age of onset of disability. Total DALYs[0,0,0] and DALYs[3,1,0.04] were calculated for each country in SSA [26].

Converting DALYs to unrealized economic benefit

Using two distinct methodologies, we determined the potential economic benefit of cleft lip and cleft palate repair for each country in SSA. For DALYs calculated without discounting and no age-weighting (i.e., DALYs[0,0,0]) and DALYs calculated with 3% discounting with the age-weighting parameter $\beta = 0.04$ (i.e., DALYs[3,1,0.04]), we multiplied the country-specific DALYs by the corresponding GNI/capita. The Gross National Income per capita (GNI/capita) for each country in 2008 was obtained from the World Bank [25]. We used the Purchasing Power Parity (PPP) method instead of the Atlas method for calculating GNI/capita, as PPP accounts better for differences in relative price levels across countries and thus likely represents the more valid cross-country measure of income per capita. Furthermore, estimates based on the PPP method are used in the authoritative review paper on income and VSL by Viscusi and Aldy [18].

We also determined the economic benefit using country-specific estimates of VSLY and age-weights consistent with those estimates. To determine the VSL for each sub-Saharan country, we used the following equation [18]:

$$VSL(CSSA) = VSL(USA) \times \left[\frac{GNI\text{p.c.}(CSSA)}{GNI\text{p.c.}(USA)}\right]^{.55}$$

where *VSL(CSSA)* is the value of a statistical life in a country in SSA, *VSL*(*USA*) is the value of a statistical life in the United States ($7.4 million), *GNI* p.c.(*CSSA*) is the GNI/capita in a country in SSA, *GNI* p.c. (*USA*) is the GNI/capita in United States ($48,000), and 0.55 is the income elasticity of VSL as suggested by Viscusi and Aldy [18]. As cleft lip and cleft palate are congenital anomalies, we also adjusted the country-specific VSLs to account for the fact that society values the life of a child (VSL-C) differently from the life of an adult; Hammitt and Haninger argue that the VSL-C is roughly 1.8 times an adult's VSL (VSL-A) [28].

To determine VSLY for a given age in each country in SSA, we used the following equation:

$$VSLY_x = V \cdot \tilde{C}xe^{-\tilde{\beta}x},$$

where

$$V = \frac{VSL}{\tilde{C}} \times \frac{\left(\tilde{\beta} + r\right)^2}{1 - e^{-(\tilde{\beta}+r)L}\left[1 + L\left(\tilde{\beta} + r\right)\right]}$$

x is the age; $\tilde{C}xe^{-\tilde{\beta}x}$ is the age-weighting function used in the DALY formula, with $\tilde{C}$ as the age-weighting correction constant; V is the VSLY without accounting for age-weighting; r is the discount rate; VSL is the value of a statistical life in SSA country; and L is the life expectancy. The twiddle mark on $\tilde{\beta}$ indicates that we calculated a unique β for each country, to ensure that VSLY peaked at 2/3 of life expectancy, which is approximately the peak reported by economics studies on the relationship between VSLY and age. As a result, the value of C was also country-specific, as it varies with β according to Table 5.2 in *The Global Burden of Disease and Risk Factors* [14]; we fit a cubic polynomial to the values in that table and used it to predict $\tilde{C}$ for a given value of $\tilde{\beta}$. We also used this country-specific β to recalculate the age-weighted DALYs, denoted by DALYs[3,1, $\tilde{\beta}$], and then estimated the economic benefit by multiplying the recalculated number of DALYs by V—not by $VSLY_x$, because DALYs[3,1, $\tilde{\beta}$] already incorporates age-weighting. After determining VSLY for adults (VSLY-A), we calculated VSLY for children (VSLY-C) by multiplying VSLY-A by 1.8.

Results

Human capital methodology

Using population data from 2008, an estimated 34,683 cleft lip and cleft palate cases occurred in sub-Saharan Africa. If all cases were treated, 146,643 DALYs[3,1,0.04] would be averted. Without adjusting for age-weighting and discounting, treatment of all clefting would avert 257,184 DALYs[0,0,0]. For cleft lip alone, treating 18,918 cases would avert 45,896 DALYs[3,1,0.04], and treating 15,765 cases of cleft palate would avert 100,747 DALYs[3,1,0.04]. Disregarding discounting and age-weighting, treating cleft lip would result in 80,493 DALYs[0,0,0] averted, and treating cleft palate would result in 176,692 DALYs[0,0,0] averted (Table 1).

When presenting the results using a human capital methodology (i.e., GNI/capita [PPP]), a range of economic benefits is presented. As discounting and age-weighting decrease total DALYs attributable to a disease, the lower bound is calculated by multiplying DALYs[3,1,0.04] by GNI/capita (PPP), and the upper bound is calculated by multiplying DALYs[0,0,0] by GNI/capita (PPP). With this human capital approach, the total economic benefit of cleft lip repair in 2008 would have been \$79 million–\$138 million. For cleft palate, the potential benefit of intervention ranged from \$173 million to \$303 million. In total, repairing both cleft lip and palate would benefit sub-Saharan Africa in the range of \$252 million–\$441 million (Table 2).

Table 1 Total DALYs averted in sub-Saharan Africa (SSA) if all new cases of clefting in 2008 were treated at birth

	Total cases	Total DALYs averted		
		3,1,0.04	0,0,0	3,1,$\tilde{\beta}$
Cleft lip	18,918	45,896	80,493	36,103
Cleft palate	15,765	100,747	176,692	79,251
Total	34,683	146,643	257,185	115,354

Table 2 Present value of potential economic benefit of cleft lip and palate repair in SSA (million \$US)

Methodology	SSA economic benefit		
	3,1,0.04	0,0,0	3,1,$\tilde{\beta}$
Cleft lip			
GNI/capita (PPP)	\$78.8	\$138.1	n/a
VSLY-A	n/a	n/a	\$1,685.4
VSLY-C	n/a	n/a	\$3,033.7
Cleft palate			
GNI/capita (PPP)	\$172.9	\$303.1	n/a
VSLY-A	n/a	n/a	\$3,699.7
VSLY-C	n/a	n/a	\$6,659.4
Cleft lip and palate			
GNI/capita (PPP)	\$251.7	\$441.1	n/a
VSLY-A	n/a	n/a	\$5,385.1
VSLY-C	n/a	n/a	\$9,693.1

Value of a statistical life-year methodology

If all of the estimated 34,683 cleft lip and cleft palate cases in sub-Saharan Africa were treated, 115,354 DALYs[3,1,$\tilde{\beta}$], would be averted. Treating all cleft lip cases would avert 36,103 DALYs [3,1,$\tilde{\beta}$], while treating all cleft palate cases would avert 79,251 DALYs [3,1,$\tilde{\beta}$].

Using VSLY-A, the economic benefit of surgical interventions to address cleft lip would have been \$1.7 billion in 2008, with the benefit of addressing cleft palate being \$3.7 billion, for a total benefit of \$5.4 billion from addressing clefting. If VSLY-C is employed, then the benefit from addressing cleft lip would have been $3.0 billion, while the benefit from addressing cleft palate was $6.7 billion, for a clefting total of $9.7 billion (Table 2).

Discussion

By estimating the total economic impact of cleft lip and palate in sub-Saharan Africa, we hope to describe in clear terms the magnitude of the morbidity caused by these surgical disease processes. This study was constructed to estimate the economic burden posed by CLP and the potential economic benefit from surgical interventions to address the condition, assuming that every case of CLP is treated at birth and that treatment reduces but does not entirely eliminate the disability. For example, if every new case of CLP in 2008 were treated, the present value of the economic benefits would be $9.7 billion, using VSLY-C in the calculation.

One way to gauge the magnitude of the monetary estimates presented in this article is to compare them to gross capital formation (GCF), which is the standard macroeconomic measure of total new investment in a region. If investments are viable, then they generate a future flow of benefits whose present value is at least as large as the sum invested. Total GCF for SSA in 2008 was $188 billion [25], which by this logic implies a present value of future benefits of at least $188 billion. The benefits of surgically addressing CLP are equivalent to 0.13–0.24% of total GCF from the human capital approach and 2.9–5.2% from the VSLY approach. Viewed as an investment in the future economic welfare of SSA, surgically addressing CLP therefore provides benefits that are surprisingly large on a macroeconomic scale. Considering that CLP is one disease among many that could be treated if an initial investment in proper surgical infrastructure were made, the potential return on investment in surgery would be even more substantial if one factored in the relatively small marginal cost of treating additional surgical diseases.

Previous studies have attempted to quantify the global burden of surgical disease using a DALY approach. As described in *Disease Control Priorities in Developing Countries* (2nd Edition), Debas et al. sent surveys to surgeons in different regions of the world and asked them to quantify the proportion of a set list of disease processes that could be treated with surgery [2]. The basket of diseases chosen originated from the 2002 World Health Report, which assigned a global burden of DALYs to each disease process. The authors then used the surveys' estimated proportion of surgical disease and calculated the percentage of DALYs that could be averted with surgery, arriving at 11%. While that study was the first attempt to put a number on the global burden of surgical disease, discerning the meaning of DALYs is not meaningful for most non-global health audiences.

We believe that reporting morbidity in economic terms is a more intuitive approach for most readers. In the 2001 *Macroeconomics and Health* report [11], Jeff Sachs suggested that using GNI/capita (i.e., the human capital approach) to value DALYs would lead to a conservative estimate of the economic loss due to disease. Corlew subsequently used this approach to estimate the individual economic benefit due to CLP repair based on patient data collected from an Interplast site in Nepal [10]. He also used VSL methodology to assign an economic benefit to CLP repair, but did not give it as much credence as the human capital approach. Notably, by calculating an age-specific and discounted VSLY that reflects the age-weighting function and discounting used in the DALY approach, and using an age-weighting parameter that is more consistent with current economic studies, we believe our VSL approach to be internally more consistent and more closely aligned with the current economics literature.

Valuing the benefits of interventions that reduce years of life lost due to premature death or disability in dollar terms is not an exact science. As demonstrated in this study, there are two basic approaches one can choose to translate DALYs into dollars, and the approach one chooses can result in values that differ from one another by orders of magnitude. The key to appreciating why disparate values occur is understanding the assumptions made by each methodology. The human capital method, which uses GNI/capita as a proxy for the benefits from averting the loss of a statistical life, assumes that a person's worth is tantamount to the market value of goods and services produced by the person's labor. This approach does not consider the possibility that someone might value a reduction in a disability by an amount that is worth, to that person, much more than what he or she can produce.

We believe that the VSL approach more likely approximates the true economic benefits from surgical interventions to address CLP. The concept of VSL has been developed over the past 40 years and is widely accepted in the academic literature. It has been officially sanctioned by government agencies in Australia and the United States [16, 20], where it is used routinely in benefit–cost analysis. Although we are unaware of any similar official endorsement by a developing country government, World Bank economists have argued that VSL "need[s] to be extended to developing countries," and the Asian Development Bank has used it in its analysis of programs to reduce road deaths in Southeast Asian countries [29, 30]. Moreover, Viscusi and Aldy report VSL studies having been conducted in Hong Kong, India, South Korea, and Taiwan [18]. Much of the appeal of VSL comes from the fact that VSL methodology uses data based on actual human behavior (see wage/risk trade-off discussion in the Introduction), and so it more accurately approximates how individuals actually value reductions in health risks. Even when VSL is approximated using different approaches, including survey-based data, calculated VSLs are typically within the same order of magnitude [21].

It is our hope that the economic benefit of CLP repair presented in this study spurs further investigation into global surgical disease and its cost to society. As attention is increasingly turned toward developing horizontal health systems (as opposed to so-called vertical programs), stakeholders should not automatically relegate surgical disease to luxury status. Rather, essential surgical services should be considered necessary for any properly functioning health system. We recognize that decision makers require more than the potential benefit of an intervention; cost must also be a consideration. Next steps, therefore, include adequately accounting for the costs of surgical intervention for specific disease processes that not only take financial costs into account but also consider the opportunity cost of these interventions. Many countries have incomplete infrastructure for surgical care delivery, and the assumption has been that it is too costly to invest the necessary capital for a more complete basket of surgical care delivery. Our data may provide support for the notion that surgical care is not only an essential component of horizontal health care in its own right, but also that any investment in surgical care, whether by foreign direct investment, governments, NGOs, or any other donor agency, can expect to generate positive returns on investment. Further study should therefore also be directed at modeling the benefits and costs of a basket of surgical diseases and procedures that represent a basic subset that any health care system should provide to justify further investment from donors.

Our study has a number of limitations. The DALY was not originally constructed to evaluate the economic benefit of medical or surgical interventions; however, given that a DALY represents a lost year of life (due to disability or premature death), it serves as a reasonable proxy for a lost year of life when one could work, create social networks, take care of one's family, or simply enjoy life. Second, the discrepant values produced in this study by using GNI/capita versus VSL might be unsettling for many readers. The value of a DALY that one accepts relies on which set of assumptions one is willing to believe. As argued above, we believe that people are worth more than what their labor produces. Combined with the fact that VSL has a more substantially developed literature and is based on observable behavior, we believe that it is indeed the more accurate estimate. Still, there is uncertainty in transferring VSL estimates from richer countries, where most estimates originate, to poorer countries, like those in sub-Saharan Africa that served as the basis for the present study. A recent report argues that the income elasticity of VSL in countries that the World Bank classifies as "low income" might be higher than the value of 0.55 that we used [31]. If true, then our VSL estimates could be too high for the 29 countries in our sample (out of 47) that are in this category.

There are also a number of assumptions made to quantify both DALYs and dollars. We used incidence data for CLP in African-Americans and assumed a similar incidence in African countries. This is clearly a generalization for citizens in SSA, oversimplifies genetic inheritance, and also ignores the different environmental contexts for each population. Unfortunately, these data are also the best incidence data available. The disability weights used, while accepted by the global burden of disease project, have their origin in expert panels and may differ significantly if one were to survey specific patient populations.

Conclusions

The idea of surgery as a necessary component of global health strategies is becoming more accepted by the global health community. The surgical community must continue to produce research that accurately gauges the benefit of surgical intervention, both in terms of DALYs and dollars. We have shown that the surgical diseases cleft lip and cleft palate can have a substantial impact on the economic health of countries in the developing world. Further studies should be directed at quantifying the economic benefits of surgical interventions and quantifying their costs with an economically sound approach.

References

1. Farmer PE, Kim JY (2008) Surgery and global health: a view from beyond the OR. World J Surg 32:533–536
2. Debas H, Gosselin R, McCord C et al (2006) Surgery. In: Jamison DT (ed) Disease control priorities in developing countries, 2nd edn. Oxford University Press, New York, pp 1245–1260
3. Kushner AL, Cherian MN, Noel L et al (2010) Addressing the millennium development goals from a surgical perspective: essential surgery and anesthesia in 8 low- and middle-income countries. Arch Surg 145:154–159
4. PLoS Editors (2008) A crucial role for surgery in reaching the UN millennium development goals. PLoS Med 5:e182
5. World Health Organization (2010) Global Initiative for Emergency and Essential Surgical Care. http://www.who.int/surgery/globalinitiative/en/. Accessed 1 Oct 2010
6. Bellagio Essential Surgery Group (2007) Increasing access to surgical services in resource-constrained settings in sub-Saharan Africa. Milan, Italy
7. McCord C (2003) A cost effective small hospital in Bangladesh: what it can mean for emergency obstetric care. Int J Gynecol Obstet 81:83–92

8. Operation Smile (2010) How Your Support Helps. http://www.operationsmile.org/about_us/how-your-support-helps.html. Accessed 1 Oct 2010
9. Magee WP Jr, Vander Burg R, Hatcher KW (2010) Cleft lip and palate as a cost-effective health care treatment in the developing world. World J Surg 34:420–427
10. Corlew DS (2010) Estimation of impact of surgical disease through economic modeling of cleft lip and palate care. World J Surg 34:391–396
11. World Health Organization Commission on Macroeconomics and Health (2001) Macroeconomics and health: investing in health for economic development. World Health Organization, Geneva
12. The World Bank (1993) World Development Report 1993: investing in health. Oxford University Press for the World Bank, New York
13. Murray CJ, Acharya AK (1997) Understanding DALYs (disability-adjusted life years). J Health Econ 16:703–730
14. Lopez AD, Mathers CD, Ezzati M et al (2006) Global burden of disease and risk factors. Oxford University Press for the World Bank, New York
15. Corlew DS (2009) Perspectives on plastic surgery and global health. Ann Plast Surg 62:473–477
16. Government of Australia (2008) Access economics: the health of nations: the value of a statistical life. Commonwealth of Australia
17. Chase SB (ed) (1968) The life you save may be your own. Problems in public expenditure analysis. Brookings Institution, Washington
18. Viscusi WK, Aldy JE (2003) The value of a statistical life: a critical review of market estimates throughout the world. J Risk Uncertain 27:5–76
19. U.S. Department of Transportation (2010) Treatment of the economic value of a statistical life in departmental analyses. http://ostpxweb.dot.gov/policy/reports/080205.htm. Accessed 31 Oct 2010
20. U.S. Environmental Protection Agency (2010) Frequently asked questions. http://yosemite.epa.gov/ee/epa/eed.nsf/pages/MortalityRiskValuation.html. Accessed 1 Oct 2010
21. Hammitt JK (2007) Valuing changes in mortality risk: lives saved versus life years saved. Rev Environ Econ Pol 1:228–240
22. Aldy JE, Viscusi WK (2008) Adjusting the value of a statistical life for age and cohort effects. Rev Econ Stat 90:573–581
23. Canfield MA, Honein MA, Yuskiv N et al (2006) National estimates and race/ethnic-specific variation of selected birth defects in the United States, 1999–2001. Birth Defects Res A Clin Mol Teratol 76:747–756
24. Mathers C, Fat DM, Boerma JT et al (2008) The global burden of disease: 2004 update. World Health Organization, Geneva
25. World Bank (2011) The World Bank: open data. http://data.worldbank.org/. Accessed 1 Feb 2010
26. Fox-Rushby JA, Hanson K (2001) Calculating and presenting disability adjusted life years (DALYs) in cost-effectiveness analysis. Health Policy Plan 16:326–331
27. Murray CJL, Lopez AD, Harvard School of Public Health et al (1996) 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, MA: Published by the Harvard School of Public Health on behalf of the World Health Organization and the World Bank; Distributed by Harvard University Press
28. Hammitt JK, Haninger K (2010) Valuing fatal risks to children and adults: effects of disease, latency, and risk aversion. J Risk Uncertain 40:57–83
29. Belli P (2001) Economic analysis of investment operations: analytical tools and practical applications. World Bank, Washington
30. Asian Development Bank (2005) Arrive alive: ASEAN commits to cutting road deaths. ASEAN Regional Road Safety Strategy and Action Plan (2005–2010). Asian Development Bank, Metro Manila
31. Hammitt JK, Robinson LA (2011) The income elasticity of the value per statistical life: transferring estimates between high and low income populations. J Benefit–Cost Anal 2(1)