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Estimation of Impact of Surgical Disease Through Economic Modeling of Cleft Lip and Palate Care

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Abstract
Background Assessing burden of disease encompasses the prevalence of disease entities, but it is the impact that affects the populace. Similarly, optimal evaluation of intervention programs shows impact rather than simply an enumeration of services. Economic effects are a fungible measure but are difficult to assess. Modeling of economic effects was used to evaluate a cleft program in Nepal and to demonstrate impact of alleviating this subset of the surgical burden of disease.
Methods The database of patients who underwent care at a cleft center in Katmandu in 2005 was used. Disability adjusted life years averted were calculated. Using both GNI per capita and Value of a Statistical Life, the economic value to the individuals and to society was calculated.
Results The two methods yielded a conservative and a generous estimate of economic impact of treating cleft lip and palate. Using GNI per capita, cleft lip repair added between $856 and $6,598 to lifetime individual income. For cleft palate, this ranged from $2,293 to $17,278. Using Value of a Statistical Life, cleft lip repair added between $56,919 and $143,363, and cleft palate between $152,372 and $375,412.
Conclusions The immense economic gain realized by an intervention addressing a small proportion of the surgical burden of disease indicates the importance of these conditions to public health and well-being. This methodology also lends itself to broader use and to further refinement as a means of evaluation of interventions. This has implications for health policy and for funding and resource allocation for surgical conditions in the developing world.

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Introduction

In an ongoing effort to gain a better understanding of the enormous cost to the health and well-being of humankind due to surgical disease, it is necessary first to learn how much of what entities affect how many people. This has been estimated and continues to be examined [1–3]. However, the next measure in this assessment is that of the *impact* of surgical burden of disease around the world. This paper describes evaluation methodology to examine the economic effect of an intervention designed to alleviate one relatively small portion of the overall surgical burden of disease.

The evaluation of health interventions can take many forms and can be applied at many levels. At the individual patient level, evaluation can examine whether the intervention achieved some predetermined goal, such as a laboratory value or healed wound, or length of hospital stay, or whether a specific complication occurred, or any other such measures. At the program level, evaluation can be of input, such as how many people underwent vaccination or a surgical procedure. Program evaluation can be of outcomes, such as comparing the number of people contracting a disease before and after a vaccination program or determining how many people had the symptoms of a problem for which they were treated in the program. Finally, evaluation can be of impact, such as the effect of the program on the life of patients or society. Such impact studies, if performed directly, can be immensely expensive, even more so than the program itself.

However, such impact is the goal of any program. An HIV prevention program, for example, may desire to decrease the incidence of new HIV infections, but the true goal is much loftier: that more people in the target group will sustain less human suffering, incur less personal and societal expense, and achieve more of their goals in life, with greater self-satisfaction and greater contribution to their own well-being, their family or other communal unit, and society. Obviously, the comparison of past or expected rates of HIV infection is much easier to measure than is the contribution to society of the cohort that is uninfected because of the program. It is assumed that a decrease in infection rate leads to the overall betterment described above.

Consequently, measurement of the greater impact of a program often is done by modeling, using what is known about the input and outcome of a program and making logical assumptions about the effects of that program on a wider scale. This necessitates health valuation, which has taken much iteration since the original suggestion by Dempsey that mortality is an inadequate measure of health [4]. The science of this concept continues to undergo evolution and requires an integrated approach between fields of clinical medicine, sociology, economics, demographics, and perhaps others [5]. The original Global Burden of Disease study, subsequently updated and currently undergoing another update, used health valuation methods to determine estimates of the effect first of 109 and then 140 disease states on human well-being [6–10]. For many of these disease states, estimates were made for both untreated and treated aspects of the conditions. Consequently, it is possible to estimate disability adjusted life years averted by an intervention that converts individuals from the untreated state to the treated state. This paper attempts to make this estimate and convert it into an economic estimate of how an intervention might affect a society. The cold perspective of economics is a quantifiable language understood universally.

For this model, a program addressing cleft care in Nepal was examined. Since 1999, the U.S.-based NGO Interplast has assisted programs based out of Katmandu Model Hospital by providing financial and educational support for the care of the poor in that country; one aspect of these programs is for people who have cleft lip and/or palate. From the inception of the program through the end of fiscal year 2008, 7,221 surgical procedures have been performed by the Nepalese surgeons in this program. Orthodontic care has been provided since 2003, and speech therapy services have been provided and made available regardless of geographic location of the patient during the past 9 years. For this study, the year 2005 was selected as a representative sample of patients treated, because that time period is the subject of the current effort to estimate the global burden of disease [11].

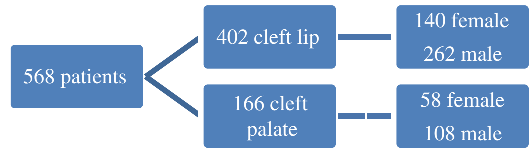

Fig. 1 Characteristics of patients in database

Methods

The database of procedures done through the Interplast Surgical Outreach Program based in Katmandu, Nepal (Interplast, 857 Maude Avenue, Mountain View, CA 94043; www.Interplast.org), during the calendar year 2005 was reviewed. During this period, 568 people underwent primary repair of cleft lip or cleft palate in this program (age range, younger than 1–28 years); 402 underwent repair of cleft lip, and 166 for cleft palate. Four underwent repair of both and are counted as separate patients. Of the patients 198 were girls or women and 370 were boys or men (Fig. 1).

Using the disability weights assigned for untreated and for treated cleft deformities by the initial Global Burden of Disease Study, disability-adjusted life years (DALYs) averted were calculated [12]. These figures were calculated both with and without the concepts of discounting and age weighting [7, 13, 14]. These admittedly are somewhat controversial [15–17]. Converting these data to economic terms could be done in any of a number of ways. For the modeling for this study, it was done very simply in two ways. First, the DALYs averted were multiplied by the Gross National Income (GNI) per capita of the country. As will be discussed below, this yields an extremely conservative estimate for multiple reasons. Second, Value of a Statistical Life (VSL) data from a developing country were used to give a different perspective on economic value. This yields a generous estimate. Value of a Statistical Life data were taken from Shanmugan's work in India [18]; because his estimate was between $569,000 and $3,103,000, the midpoint of these figures ($1,836,000) was used for this paper. If life expectancy is considered to be 81.25 (female 82.5, male 80.0), this yields an estimate of VSL per year of life of $22,597.

Results

Because the GBD study did not differentiate between unilateral and bilateral cleft lip, these two entities are by necessity considered as one. For cleft lip, a total of 2550.4 DALYs were averted by the program if age weighting and discounting were not considered. With these two factors included, this figure was 1012.6. For cleft palate, these figures were 2757.8 and 1119.3, respectively. For the condition of cleft lip, using only GNI per capita in the economic conversion, the program resulted in an addition to Nepalese society of $6,598 calculated by Purchasing Power Parity (PPP)[1] ($2,157 by Atlas method) per person if age weighting and discounting were not considered; $2,620 PPP ($856 Atlas) if these factors were included. The total value for all patients was $2,652,434 PPP ($867,143 Atlas) without considering age weighting and discounting. For cleft palate, this methodology indicates an individual economic gain per year of $17,278 PPP ($5,649 Atlas), or $7,013 PPP ($2,293 Atlas), depending on whether age weighting and discounting are considered. The total value for all cleft palate patients was $2,868,130 PPP ($1,164,113 Atlas).

Using Value of a Statistical Life data, people who underwent cleft lip correction saw a lifetime increase in economic productivity of $143,363 or $56,919, again depending on whether age weighting and discounting were considered. For all patients with cleft lip, these figures were $57,631,770 and $22,881,627, respectively. For cleft palate, these figures were $375,412 and $152,372, respectively. Aggregate total for these patients was $62,318,395 and $25,293,709.

Also pertinent to this evaluation is the cost of these interventions. The average cost of each procedure, including all of the actual costs of the supplies, hospital costs, patient transport, and costs of staff time was $275 (including approximately $15 per patient for the cost of the speech therapy program). This indicates a cost per DALY averted of $73 if age weighting and discounting are not considered and $29 if they are included in the calculations (Tables 1, 2).

Table 1 DALYs averted and economic gain using GNI per capita

Cleft lip	0,0*	3,1
Total DALYs averted	2550.4	1012.6
Economic gain PPP (USD)	$2,652,434	$1,053,100
Economic gain Atlas (USD)	$867,143	$344,283
Economic Gain PPP per pt (USD)	$6,598	$2,620
Economic Gain Atlas per pt (USD)	$2,157	$856
Cleft palate	0,0	3,1
Total DALYs averted	2757.8	1119.3
Economic gain PPP (USD)	$2,868,130	$1,164,113
Economic gain Atlas (USD)	$937,658	$380,575
Economic Gain PPP per pt (USD)	$17,278	$7,013
Economic gain Atlas per pt (USD)	$5,649	$2,293

* 0.0 indicates no age weighting or discounting; 3.1 indicates 3% discounting and age weighting as used in the Global Burden of Disease study

Table 2 DALYs averted and economic gain using Value of a Statistical Life

Cleft lip	0,0	3,1
Total DALYs averted	2550.4	1012.6
DALYs averted per pt	6.3	2.5
Economic Gain VSL	$57,631,770	$22,881,627
Economic Gain per pt VSL	$143,363	$56,919
Cleft palate	0,0	3,1
Total DALYs averted	2757.8	1119.3
DALYs averted per pt	16.6	6.7
Economic gain VSL	$62,318,395	$25,293,709
Economic gain per pt VSL	$375,412	$152,372

Discussion

This study attempts to quantify in economic terms the value of health services to individuals and to society. The disability adjusted life years averted and the commensurate increase in income over the lifetime of people undergoing a discrete intervention (e.g., repair of cleft lip or cleft palate) are estimated. Although the association between health and income is well-accepted, the actual coupling of the two is difficult. Many efforts to do so consider life expectancy as a health measure (i.e., using mortality as the health measure rather than considering non-fatal health states), and macroeconomic population income growth rather than the microeconomic effects on individuals [19, 20].

It is evident that modeling of this sort requires multiple assumptions, beginning with incorporating all of those that went into the determination of the weighting factors in the original GBD study that gave rise to the concept of DALYs. We then are faced with the concept of what constitutes a "treated" problem in GBD weighting factors. For the model used in this study, this applies clinically to the conditions of cleft lip and cleft palate. For cleft lip, it is reasonable to assume that the major aspect of such treatment is the operative repair. In developed countries, some (perhaps many) of these patients will eventually require revision, rhinoplasty, orthodontics, or orthognathic procedures. These services are performed routinely in the center that is the subject of this report, but nevertheless with less frequency than in developed countries. The relevance of these procedures is not included in the statistical analysis

[1] Purchasing Power Parity considers the varying prices of goods between national economies; the Atlas method of computing Gross National Income measures income in terms of currency equivalents, but also considers fluctuations in exchange rates. See http://www.who.int/choice/costs/ppp/en/ for more information on PPP and http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,,contentMDK:20173256~isCURL:Y~menuPK:64133156~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html for more information on economic assessment of countries.

comprising the study. In the developed world, "treated" cleft palate could be construed as including long-term speech therapy, orthodontic care that often is complex, sometimes revisional procedures for velopharyngeal insufficiency, otologic interventions, in some cases maxillofacial procedures, and psychological counseling for the child and family. Some of these entities are provided in this center in Nepal; a speech therapy program has been designed there to meet the unique needs of the populace. Orthodontic care is available, although resources limit this to some degree. VPI is addressed as indicated, and maxillofacial surgery also is within the capability of the surgeons in Katmandu, although perhaps less aggressively prescribed than is the case in the United States.

In the assignment of weighting factors of the conditions addressed in the GBD, the methodology of the GBD study attempted to take a holistic view of the problems addressed. Although the vast economic literature describing the production function is beyond the scope of this study, there are many factors that contribute to individual productivity that are affected by the health issues resulting from cleft deformities. In many societies, an unrepaired cleft lip or cleft palate results in social stigma not only for the affected person, but often for the entire family. This also generally leads to lack of schooling, which leads to decreased employment opportunities. All of the problems that would be addressed by the services described above, such as diminished intelligibility of speech, recurrent otitis media with hearing loss, and nasal regurgitation of food and secretions seen with cleft palate, contribute to the social isolation inherent with these difficulties. This social isolation can be an overriding factor; repair of the deformity results in significant improvement in standard of living across many domains. Whether, at the level of the individual person, all of these factors are taken into consideration with the weighting factors can only be a matter of conjecture. Consequently, it could be argued that there should be further considerations than the value of DALYs in an economic model. As discussed below, education is perhaps the most applicable factor for this argument.

For health problems that largely affect children, education is of critical lifelong importance. The lack of educational opportunities as a child seals an individual's limitations in the work force. Estimates of the effect of education on economy have generally looked at populations rather than individuals. Barro found a strong correlation between school enrollment and growth of GDP which was assessed further by Bils and Klenow [21, 22]. Acemoglu and Angrist estimated that each year of schooling resulted in a 6% to 10% increase in income, and further stated that the social returns on investment in education result in a greater effect than is estimated directly [23]. In a preliminary study, Ashraf et al. included schooling in an estimate of human capital, after a model of Hall and Jones. In this model, the effect of 6 years of schooling was estimated by the formula:

$$\begin{aligned}\text{Human capital gained} &= \exp[(4)(0.134) + (6-4)(0.101)]\\ &= \exp 0.738 = 2.09.\end{aligned}$$

The Figs 0.134 and 0.101 are constants related to the effect of 4 years and between 4 and 8 years of schooling, respectively [24, 25]. This indicates that lifetime income is slightly more than doubled by a mere 6 years of schooling. It could be argued that the economic estimates of this study should be adjusted to reflect this.

Developed by Thaler and Rosen in 1975 [26], the concept of VSL can be criticized as being overly hypothetical. However, it arguably is quite appropriate for considering social, educational, and health factors. The increase in utility of having a presentable face or proper communication skills is difficult to quantify. For repair of these deformities, the gain of a few years of disability-free life seems to trivialize the burden of living with the deformity. VSL methodology attempts to consider these factors more completely.

VSL, however, is difficult to assess, and can be construed to be culture- or economy-specific. Viscusi and others, assessing U.S. workers, found an annual value of \$170,000 to \$200,000, and a lifetime value of 4 to 9 million dollars [27, 28]. Using Environmental Protection Agency data, Aldy and Viscusi estimated the value of a statistical year to be \$275,000, or VSL of 6.3 million dollars [29]. Although ethical arguments can be made regarding regional, national, and cultural differences in VSL, it was deemed that data from a developing Asian country was more applicable to the individuals whose treatment was assessed in this study. Shanmugan's work from India during the late 1990s was found to be most appropriate [18].

The use of age weighting and perhaps more importantly, discounting, diminish the calculated DALYs significantly, and it can be argued that the findings of this study are arguments against the use of these factors, at least applied to these particular health problems. There also is greater uncertainty in the weighting factors for nonfatal causes of disease [30]. The risk of death could be construed as a reason to use discounting, but otherwise the effect of a cleft and the effect of the repair do not intrinsically lend themselves to having lesser value in the future. Similarly, regarding age weighting, these defects (and their repair) intuitively do not seem to have lesser value in the young or the old. Education and social development often can only be done in the young, yet there is a lifelong economic effect of these two entities. For these problems, the interventions in this population demonstrate arguments against the use of discounting and age weighting in assessing non-fatal health outcomes, as the effects of the cleft and of the repair are uniformly distributed throughout life.

Regarding the cost of these interventions, the World Health Organization in its World Health Report of 2002 stated, “interventions costing less than 3x GDP per capita for each DALY averted represent good value for money” [31]. The figure of 29 to 73 USD per DALY averted represents only a fraction of this WHO suggestion.

This model utilizes GNI per capita as an estimate for the economic contribution of an individual. There are several possible criticisms of this approach. This method calculates income gained directly as a function of the added years of productivity. It assumes that the years gained are productive ones. Although a very reasonable assumption, it is essentially impossible to verify this experimentally. For the purposes of this study, it was postulated that patients are assumed to be economically substitutable. This may not be true in relation to gender in view of the effect of gender bias resulting in diminution of the economic opportunities of women.

Another significant shortcoming of using GNI per capita as an estimate of economic contribution is that this markedly underestimates value by ignoring the externalities of the potential economic gain for the parents of the child with a cleft. Having a child with any disability creates significant financial obstacles for the caregiver parents, and this is probably more likely in a developing country without the safety nets that can provide assistance. It is reasonable to assume that such a domestic situation can effectively remove one parent at least partially from the workforce. This is a reasonable statement for a significant disability at any age; a caregiver is necessary to some degree, with commensurate decrease in workforce productivity from that caregiver.

Perhaps the greatest shortcoming of this methodology, however, is that it ignores the utility factor of the loss of socialization, of fulfillment of productivity, and general well-being that is denied those with such deformities. The Commission on Macroeconomics and Health of the World Health Organization suggested that three times the GNI per capita might be a more appropriate estimate of economic loss [32]. This is an effort to capture some of these factors in the estimate of economic loss, and perhaps addresses the effect on caregivers of health loss. This was addressed in this study by also calculating economic value using VSL methodology. These estimates are far greater than those using GNI per capita, because it is a more holistic measure.

Finally, it is recognized that DALYs are intended to be used to assess population health, not individual health as is done in this paper. However, the DALY is a reasonable measure when applied to a program of this size. The “population” in question is that of the program. The smaller size of the population calls into question the use of DALYs because of the uncertainty of the weighting factors.

Conclusions

Determining the global burden of surgical disease is a many-faceted task. Obtaining the number of people affected and the magnitude of their disabilities that could be alleviated by surgical intervention is uppermost, but the benefit of addressing these problems is important for directing resources and making health policy. Program evaluation can be a difficult task, and the farther along in the continuum of input, output, outcomes, and impact, the more useful the evaluation for policy purposes.

This study uses existing data to evaluate impact of an intervention program in economic terms. Such evaluation gives an estimate of what the program accomplished for individuals and for society, and what it can be expected to accomplish over the long-term without incurring the costs of a decades-long and extremely expensive follow-up evaluation. It is hoped that this concept can be refined with better methods of economic conversion, better health valuation methodology for individuals, and with more detailed input from the program being evaluated.

The immense economic gain realized by addressing of what is actually a small fraction of the surgical burden of disease indicates that funding and resource allocation for surgical conditions is of enormous importance to societies. The cost per DALY averted of between $29 and $73 is acceptable by any standards. The economic gain is considerable and is achieved by a specific intervention. This is consistent with the assertion that addressing surgical needs as a priority is critical to and an integral part of the health of the public.

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