Global Cost-effectiveness of Cataract Surgery

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Van C Lansingh
Help Me See and IMO

Marissa J Carter
Independent Researcher

Global Cost-effectiveness of Cataract Surgery

Van C. Lansingh, MD, PhD,[1] Marissa J. Carter, MA, PhD,[2] Marion Martens[1]

Objective: To determine the cost-effectiveness of cataract surgery worldwide and to compare it with the cost-effectiveness of comparable medical interventions.

Design: Meta-analysis.

Participants: Approximately 12 000 eyes in the studies selected.

Methods: Articles were identified by searching the literature using the phrase *cataract surgery*, in combination with the terms *cost*, *cost-effectiveness*, and *cost-utility*. Terms used for the comparable medical interventions search included *epileptic surgery*, *hip arthroplasty*, *knee arthroplasty*, *carpal tunnel surgery*, and *defibrillator implantation*. The search was restricted to the years 1995 through 2006. Cataract surgery costs were converted to 2004 United States dollars (US$). Cost-utility was calculated using: (1) costs discounted at 3% for 12 years with a discounted quality-adjusted life years (QALY) gain of 1.25 years, and (2) costs discounted at 3% for 5 years with a discounted QALY gain of 0.143 years. The Cataract Surgery Affordability Index (CSAI) for each country was calculated by dividing the cost of cataract surgery by the gross national income per capita for the year 2004.

Main Outcome Measures: Cost-utility in 2004 US$/QALY and affordability of cataract surgery relative to the United States.

Results: Cost-utility values for cataract surgery (first eye) varied from $245 to $22 000/QALY in Western countries and from $9 to $1600 in developing countries. In developed countries, the cost-effectiveness of cataract surgery estimated by Choosing Interventions That Are Cost Effective ranged from, in international dollars (I$), I$730 to I$2400/disability-adjusted life years (DALY) averted, and I$90 to I$370/DALY averted in developing countries. The CSAI varied from 17% to 189% in developed countries and 29% to 133% in developing countries compared with the United States. The cost-utility of other comparable medical interventions was: epileptic surgery, $4000 to $20 000/QALY; hip arthroplasty, $2300 to $4800/QALY; knee arthroplasty, $6500 to $12 700/QALY; carpal tunnel surgery, $140 to $280/QALY; and defibrillator implantation, $700 to $23 000/QALY.

Conclusions: The cost-utility of cataract surgery varies substantially, depending how the benefit is assessed and on the duration of the assumed benefit. Cataract surgery is comparable in terms of cost-effectiveness to hip arthroplasty, is generally more cost-effective than either knee arthroplasty or defibrillator implantation, and is cost-effective when considered in absolute terms. The operation is considerably cheaper in Europe and Canada compared with the United States and is affordable in many developing countries, particularly India.
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In 1990, the number of blind persons in the world was estimated at 38 million.[1] Twelve years later, this number had not substantially changed, and moreover, the 2002 data indicated 124 million individuals with low vision and more than 161 million who were visually impaired using the International Classification of Diseases definition of best-corrected visual acuity.[2] During this period, the leading cause of blindness was cataract, which steadily increased as a cause of blindness to nearly 48% in 2002.[1,2] With a rapidly aging population in many countries that continues to exacerbate the prevalence of visual impairment, the World Health Organization and the International Agency for the Prevention of Blindness joined forces in 1999 to respond to the problem, which resulted in the launch of VISION 2020: The Right to Sight global initiative.[3] The chief goal of this program is to eliminate avoidable blindness by the year 2020, and if the planned interventions succeed, Frick and Foster[4] estimate that some 52 million persons will have their sight saved, with the concurrent avoidance of 429 million blind person-years, and an economic gain of $102 billion. To achieve this lofty target, one of VISION 2020's specific objectives is to increase the availability of cataract surgery globally by raising output and training ophthalmic surgeons, especially in undeveloped and developing countries.

In 1993, the World Bank Report titled Investing in Health[5] described cataract surgery as a relatively cost-effective intervention. To understand what the term *cost-effective* means, it is necessary to describe briefly the measures that are used currently. The first is *cost-minimization analysis*.[6,7] Typically, such an analysis compares 2 interventions of comparable effectiveness to determine which is

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[1] Fundacion Vision, Asuncion, Paraguay.

[2] Strategic Solutions, Inc., Cody, Wyoming.

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Correspondence to Marissa Carter, Strategic Solutions, Inc., 1143 Salsbury Avenue, Cody, WY 82414. E-mail: strategicsolns@aol.com.

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the less costly. A *cost-benefit analysis* compares the costs of an intervention against the money saved as a result and is widely used in healthcare policy decisions.[6,7] However, quality-of-life issues are ignored. Cost-benefit analyses frequently are used in situations in which the resource allocations of fixed budgets are likely to be impacted when adopting new treatments that might be more costly but more effective. The *cost-effectiveness analysis* is a more specific version of the cost-benefit analysis in that the output (benefit) is measured on a different scale, rather than in monetary terms.[6,7] Output units usually are specified in terms of life-years gained or saved, derivations—for example, disability-adjusted life years (DALYs)—averted, or vision-years in ophthalmic interventions, although they could include life-threatening events averted, so that an overall output is cost per output unit. All these measurements, however, do not take into account the value perceived by the recipient of an intervention. Any cost-effectiveness analysis that does so is termed a *cost-utility analysis* and lies at the heart of value-based medicine.[6,7]

To calculate the quality-of-life parameter (utility), a scale of 0 to 1 is constructed, with 0 representing death and 1 representing perfect health, whereas on an ophthalmic basis, 1 would represent perfect vision and 0 would represent complete blindness. No light perception in both eyes, for example, has been rated at 0.26.[8]

Several methods have been used commonly to determine utility values. In the time trade-off approach, an individual is asked first how many years he or she is expected to live, followed by how many years he or she would be willing to trade in return for perfect health, or in ophthalmic terms, perfect vision. Thus, if the person expected to live another 10 years and was willing to trade 4 of them, the utility value would be calculated as $1.0-4/10 = 0.6$. In the standard gamble variant, a person is usually asked what risk of death he or she is willing to accept before declining treatment in a scenario in which treatment either succeeds completely (perfect health) or yields death, albeit instantly and painlessly (under anesthesia, for example). Thus if the highest risk is 30%, the utility value is $1.0-0.3 = 0.70$.

Although the standard-gamble method has long been considered the gold standard,[9–11] it can be interpreted as cognitively demanding[12,13] and overestimating risk aversion.[9,14] In response to these and other issues arising from the standard-gamble method, some researchers have advocated developing an alternative form of measurement, such as the health year equivalent in lieu of the quality-adjusted life year (QALY).[15] Although the time trade-off approach does incorporate the time element, it has been criticized[16] because it does not meet the original utility criteria discussed by Von Neumann and Morgenstern,[17] which specify how a rational person makes decisions in the presence of uncertainty, that is, the approach is not grounded in risk theory. Nevertheless, the time trade-off method has been found to correlate better with vision and quality-of-life issues in ophthalmology rather than the standard gamble.[12]

The third method to obtain utility data is the self-assessment scale, which uses input from patients, clinicians, and communities to arrive at utility values.[18] Kassirer[13] argued that although clinicians and expert panels might possess a more accurate overall picture of cost-effectiveness, patient data should be emphasized because they determine what is important to the patient. In contrast, in its assessment of QALY-based research, the United States Panel on Cost-effectiveness in Health and Medicine recommended the community-based approach.[19] Self-assessment scales do have limitations, however, and issues of adaptability, scales of reference, and age have emerged,[18,20,21] although corrective procedures also have evolved. In the field of ophthalmology, some of the more popular self-assessment instruments include the 14-item Visual Function Questionnaire (VFQ)[22] and the modified 14-item VFQ,[12] the 25-item VFQ,[23] formerly known as the National Eye Institute Visual Function Questionnaire,[24] the Euro Quality of Life assessment,[25] and more recently, the Visual Quality of Life assessment.[26]

Cost-utility is an excellent measure of assessing cost-effectiveness on an individual basis, but how can the cost-effectiveness of a large program or a health intervention implemented at a national level be measured? The answer lies in the Choosing Interventions That Are Cost Effective methodology advocated by the World Health Organization.[27,28] The cost side of the equation is difficult to quantify but makes use of a concept called the *international dollar* (I$), which is the amount of a currency required to purchase the same quantity of goods and services as $1 could purchase in the United States.[29] Costs are divided into program-level costs, typically resources required to establish and maintain an intervention, and costs borne by the recipients of an intervention, such as medicine, outpatient, or inpatient stays. The effectiveness portion is calculated by determining the number of DALYs averted by implementing an intervention versus the base case of not doing anything, with the advantage that cost-effectiveness also can be estimated by combining different interventions. Disability weights for different health states and diseases are taken from the published literature. In general, a population coverage of 80% is used in the model,[29] but modeling other coverage values is possible.

In this article, we review the literature from 1995 onward to determine how cost-effective cataract surgery is, focusing on cost-utility. Using cost data from several different countries, we calculate cost-utility by 2 different methods and also develop a Cataract Surgery Affordability Index to assess how affordable the surgery is for developed and developing countries. We also discuss the factors that affect the calculation of cost-utility. Finally, the cost-effectiveness of cataract surgery is compared against 5 other medical interventions that involve surgery and are age related to varying degrees: epileptic surgery, surgery for carpal tunnel syndrome, hip arthroplasty, knee arthroplasty, and defibrillator implantation.

Materials and Methods

Relevant articles were identified by first searching MEDLINE, MEDSTAR, CINAHL, COCHRANE, Healthstar, EMB Reviews, and the National Library of Medicine (PubMed) databases using the key phrase *cataract surgery*, in combination with the terms *cost*, *cost-effectiveness*, and *cost-utility*. The terms used for the comparable medical interventions search included *epileptic surgery*, *hip arthroplasty*, *knee arthroplasty*, *carpal tunnel surgery*, and *defibrillator* and *implantation* in combination with the same cost terms. The search was restricted to the years 1995 through 2006. Papers written in languages other than English were not excluded from this process and were translated if the abstract was insufficient to provide key data. Further literature sources were found by reviewing the reference lists of all papers. Articles selected for evaluation (approximately 200) contained data concerning (1) costs of cataract surgery, (2) measures of cost-effectiveness of cataract surgery, or (3) both. Papers specifically dealing with intraocular lenses were excluded.

For those studies that provided only cost data for cataract surgery, costs were converted to 2004 United States dollars (US$) by using Federal Reserve historical foreign exchange rates (http://www.federalreserve.gov/RELEASES/H10/hist) and consumer price index data for urban consumers (http://www.bls.gov.proxy.lib.umich.edu/data). To explore sensitivity, 2 methods were used to calculate cost-utility: (1) costs were discounted at 3% for 12 years and a discounted QALY gain of 1.25 years was used—this method assumes a 12-year life expectancy and a utility gain of 0.148 per operation for the first eye[30]; and (2) costs were discounted at 3% for 5 years and a discounted QALY gain of 0.143 years was used—this method assumes a 5-year life expectancy and a utility gain of 0.0332 for the first eye (similar to one of the methods reported by Kobelt et al[25]). We also developed a Cataract Surgery Affordability Index (CSAI) for each country by dividing the cost of cataract surgery by the gross national income per capita for the year 2004 using economic data from the World Bank (http://web.worldbank.org).

Results

Comparatively few studies[25,30–32] have been published that provide rigorous and transparent cost-utility data on cataract surgery in the form of QALYs per unit of currency. A summary of these studies is shown in Table 1.

Kobelt et al[25] performed a prospective cost-utility study of 485 Swedish patients in 4 centers undergoing cataract surgery for the first eye and in regression analyses found good agreement between visual acuity, as measured by logarithm of the minimum angle of resolution (logMAR) units with the calculated utilities (Euro Quality of Life method) or Catquest (a disease-specific, health-related quality-of-life instrument measuring the benefit of surgery as a function of a patient's specifics at baseline) score, although the utility change per logMAR unit or Catquest point was small. When cost data and both vision and disability scores were considered, the cost-utility of cataract surgery was determined to be US$4800/QALY in 2006 United States dollars using the commonly accepted discounted benefit of 3%.

Busbee et al[30] retrospectively analyzed the United States arm of the National Cataract Patient Outcomes Research Team study, conducted in 1991, which included both phacoemulsification and extracapsular cataract extraction procedures (ratio of 2:1) conducted for 722 individuals. Complications arising for a 4-month period after surgery were taken from patient data supplemented by estimated rates from the literature for various complications. Patient visual acuity data and utility values derived from time trade-off methods, corresponding to visual states and particular postoperative complications, then were incorporated into a decision analysis program. The mean gain of 1.78 QALYs per patient, calculated for a median age of 73 years and life expectancy of 12 years, compares with a gain of 0.14 QALYs per patient for the study by Kobelt et al[25] in which the mean age was 78 years and the assumed life expectancy was 5 years.

Using the same methodology, Busbee et al[31] also explored the cost-utility of cataract surgery in the second eye in the same Patient Outcomes Research Team study cohort, and found that 0.92 QALYs were gained per patient using a 3% discount. This figure is close to the cost-utility for the first eye reported by the same authors,[30] indicating that the cost-utility for surgeries of both eyes are similar when calculated using the same methodology. A recent study in Finland by Räsänen et al[32] of 219 patients with a mean age of 71 years, however, found utility gains of only approximately 0.01 regardless of whether 1 or both eyes were subject to cataract surgery.

Aribaba retrospectively studied cataract surgeries, some of which were combined with other ophthalmic surgeries, in Nigeria from 2000 through 2004 and determined cost-utility using the methodology of Busbee et al[30] (Aribaba OT. Cost effectiveness analysis of cataract services in Lagos University Teaching Hospital [LUTH], Lagos, Nigeria [master's thesis summary]. Available at: http://www.iceh.org.uk/alumni/more/aribaba04.htm. Accessed December 1, 2006). The results were similar to those of Busbee et al[30] (Table 1), indicating that surgery costs in Nigeria are surprisingly high compared with other developing countries in Africa.

Using the World Health Organization's Choosing Interventions That Are Cost Effective methodology, Baltussen et al[33] estimated the cost-effectiveness of cataract surgery for extracapsular cataract extraction (ECCE)–posterior chamber intraocular lens implantation using 80% coverage and a 3% discounted rate globally as follows (all figures are quoted in 2000 I$/DALY averted): Africa, $91 to $106; North America and Cuba, $726; Central and South America, $139; Western Europe, $1297; Eastern Europe, $156 to $373; Asia (developed countries), $2373; and Asia (developing and undeveloped countries), $54 to $123. In this study, although

Table 1. Studies Reporting Cost-Utility of Cataract Surgery Using Intraocular Implants for First Eye (Unless Otherwise Stated)

Study	Year Published	Country	Cost-Utility (US$/QALY)	Method Used for Utility	Remarks
Aribaba*	2004	Nigeria	1928–2875	TTO	Cost-utility for 4 different scenarios
Busbee et al[30]	2002	United States	2020	TTO	Costs/QALYs discounted 3% over 12 yrs (life expectancy)
Busbee et al[31]	2003	United States	2727	TTO	Cost-utility surgery for second eye
Kobelt et al[25]	2002	Sweden	4900	EQ-5D and Catquest	Undiscounted costs; QALYs discounted 3% over 5 yrs (life expectancy); correlation of Catquest and EQ-5D
Räsänen et al[32]	2006	Finland	13 018	15D	QALYs discounted 3%; costs not discounted; life expectancy unknown

EQ-5D = Euro Quality of Life; QALY = quality-adjusted life years; TTO = time trade-off.
*See text for reference citation.

Table 2. Cost-Utility of Cataract Surgery for the First Eye Calculated for Different Countries

Country	Year Costs Calculated	Cost Cataract Surgery ($)	Cost-Utility ($/QALY)	Reference (Costs)
Australia	1993	PH: (a) 759, (b) 939; ECCE: (a) 617, (b) 764	PH: (a) 607, (b) 6566; ECCE: (a) 494, (b) 5343	Asimakis et al[34]
Australia	1995	OUT: (a) 1257, (b) 1556; IN: (a) 1471, (b) 1820	OUT: (a) 1006, (b) 10 881; IN: (a) 1177, (b) 12 727	Fan et al[35]
Brazil	2000	PH: (a) 185, (b) 227	(a) 148, (b) 1587	Filho et al[36]
Canada	2003/2004	(a) 288, (b) 353	(a) 245, (b) 2467	Chen and Arshinoff[37]
France	2000	OUT: (a) 823, (b) 1018; IN: (a) 1176, (b) 1455	OUT: (a) 658, (b) 7119; IN: (a) 941, (b) 10 175	Nghiem-Buffet et al[38]
Germany	2003	OUT: (a) 722, (b) 893; IN: (a) 1390, (b) 1720	OUT: (a) 578, (b) 6245; IN: (a) 1112, (b) 12 028	Landwehr et al[39]
India	2000	PH: (a) 19.4, (b) 23.8; ECCE: (a) 12.4, (b) 15.2 MSICS: (a) 13.0, (b) 15.9	PH: (a) 15.5, (b) 166; ECCE: (a) 9.9, (b) 106 MSICS: (a) 10.4, (b) 111	Muralikrishnan et al[40]
India	2004	ECCE: (a) 11.0, (b) 13.8; MSICS: (a) 10.9, (b) 13.3	ECCE: (a) 8.78, (b) 96.5; MSICS: (a) 8.70, (b) 93.0	Gogate et al[41]
Malaysia	2000	PH: (a) 878, (b) 1075; ECCE: (a) 706, (b) 865	PH: (a) 702, (b) 7514; ECCE: (a) 565, (b) 6046	Loo et al[42]
Malaysia	2001	PH: (a) 396, (b) 485; ECCE: (a) 333, (b) 408	PH: (a) 317, (b) 3390; ECCE: (a) 266, (b) 2852	Rizal et al[43]
Nepal	1992	ECCE: (a) 20.3, (b) 24.8	(a) 16.2, (b) 173	Marseille[44]
Nepal	1997	ECCE: (a) 16.3, (b) 19.9	(a) 13.0, (b) 139	Ruit et al[45]
Spain	1999	OUT: (a) 710, (b) 879; IN: (a) 864, (b) 1070	OUT: (a) 568, (b) 6147; IN: (a) 691, (b) 7483	Castells et al[46]
Sweden	1998	(a) 607, (b) 743	(a) 486, (b) 5194	Lundström et al[47]
Tanzania	2004	ECCE: (a) 9.7, (b) 11.9	(a) 7.8, (b) 83.2	Lewallen et al[48]
UK	1993	CC: (a) 690, (b) 844; GOS: (a) 786, (b) 963	CC: (a) 552, (b) 5900; GOS: (a) 629, (b) 6731	Cresswell et al[49]
USA	2004	(a) 2525, (b) 3091	(a) 2020, (b) 21 606	Busbee et al[30]

CC = cataract center; ECCE = extracapsular cataract extraction; GOS = general ophthalmic services; IN = overnight stay in hospital; MSICS = manual small-incision cataract surgery; OUT = day surgery; PH = phacoemulsification; QALY = quality-adjusted life year.
Costs were standardized to 2004 US$ and either discounted at (a) 3% for 12 years, or (b) 3% at 5 years. QALY gain used was either (a) 1.25 years (Brown et al,[30] discounted 3% over 12 years), or (b) 0.143 years (Kobelt et al,[26] discounted 3% over 5 years).

I$1 is equivalent to US$1, the cost-effectiveness figures are not directly comparable with the cost-utility data already presented; nevertheless, the data are extremely useful, because direct comparisons can be made between regions.

Because costs for cataract surgeries were available from many other countries, we developed cost-utility data for each study using utility figures taken from the research of Busbee et al[30] and Kobelt et al[25] to provide a range. These data are shown in Table 2. Table 3 shows the undiscounted costs of cataract surgery from the same studies, together with gross national income per capita data, allowing the calculation of the CSAI. In general, it was found that surgery costs were much less in Europe compared with the United States, and costs in Canada were even lower. Outpatient surgery seems to be much cheaper than surgery involving an overnight stay, regardless of country, and phacoemulsification was more expensive than either ECCE or manual small-incision cataract surgery. In terms of affordability, the operation is much more affordable in Western Europe compared with the United States, most affordable in Canada, and far less affordable in developed countries in Asia. Among the developing countries in Asia, cataract surgery is the most affordable in India.

To compare the cost-effectiveness of cataract surgery with other medical interventions, we selected interventions that most matched the conditions of cataract surgery, that is, those that involved surgery, were age related, and were not performed under life-threatening conditions: epileptic surgery, surgery for carpal tunnel syndrome, hip arthroplasty, knee arthroplasty, and defibrillator implantation. These data are shown in Table 4. Based on a comparison of the data in Tables 2 and 4, the cost-utility of cataract surgery is similar to that of hip arthroplasty, higher than that of the surgery to correct carpal tunnel syndrome, but generally lower than that of knee arthroplasty, epileptic surgery, and defibrillator implantation.

Discussion

Our results show that the cost-utility of cataract surgery can vary significantly. To determine how cost-effective the surgery is on a global basis and how it compares against other medical interventions, it is necessary to discuss the factors that impact the calculation. The first issue is one of duration of benefit. Because cost-utility studies of cataract surgery reported to date include only short follow-up periods of 4 months or fewer, is it correct to conclude that such cost-utility values derived are still valid, if the lifetime of the surgery is considered in its entirety? Lundström and Wendel[66] attempted to answer this question by determining how long the improved visual function lasts after cataract surgery. Their retrospective study included 615 Swedish patients who underwent surgery between 1995 and 2002 and were assessed before surgery and 1 year and 8 years after surgery, using clinical data and the Catquest questionnaire. The main finding was that 7 years after surgery, 80% still enjoyed improved visual function. Further, within the limitations of the study, neither age nor new general diseases

Table 3. Affordability of Cataract Surgery

Country	Cost of Cataract Surgery ($) (Reference)	Gross National Income per Capita ($)	Cataract Surgery Affordability Index	Cataract Surgery Affordability Index Relative to United States (%)
Australia	Phaco, 1094 ECCE, 890	27 070	Phaco, 0.040 ECCE, 0.033	Phaco, 46.0 ECCE, 37.9
Australia	Outpatient, 1812 Inpatient, 2120	27 070	Outpatient, 0.070 Inpatient, 0.078	Outpatient, 80.5 Inpatient, 89.7
Brazil	Phaco, 264	3000	0.088	101
Canada	411	28 310	0.015	17.2
France	Outpatient, 1186 Inpatient, 1695	30 370	Outpatient, 0.039 Inpatient, 0.056	Outpatient, 44.8 Inpatient, 64.4
Germany	Outpatient, 1040 Inpatient, 2004	30 690	Outpatient, 0.034 Inpatient, 0.065	Outpatient, 39.1 Inpatient, 74.7
India	Phaco, 27.7 ECCE, 17.7 MSICS, 18.5	630	Phaco, 0.044 ECCE, 0.028 MSICS, 0.029	Phaco, 50.6 ECCE, 32.2 MSICS, 33.3
India	ECCE, 15.7 MSICS, 15.5	630	ECCE, 0.025 MSICS, 0.025	ECCE, 28.7 MSICS, 28.7
Malaysia	Phaco, 1252 ECCE, 1007	4520	Phaco, 0.277 ECCE, 0.223	Phaco, 318 ECCE, 256
Malaysia	Phaco, 565 ECCE, 475	4520	Phaco, 0.125 ECCE, 0.105	Phaco, 144 ECCE, 121
Nepal	ECCE, 28.9	250	0.116	133
Nepal	ECCE, 23.2	250	0.093	107
Spain	Outpatient, 1024 Inpatient, 1246	21 530	Outpatient, 0.048 Inpatient, 0.058	Outpatient, 55.2 Inpatient, 66.7
Sweden	865	35 840	0.024	27.6
Tanzania	ECCE, 13.8	320	0.043	49.4
United Kingdom	CC, 983 GOS, 1121	33 630	CC, 0.029 GOS, 0.033	CC, 34.3 GOS, 37.9
United States	3600	41 440	0.087	100

CC = cataract center; ECCE = extracapsular cataract extraction; GOS = general ophthalmic services; inpatient = overnight stay in hospital; MSICS = manual small-incision cataract surgery; outpatient = day surgery; phaco = phacoemulsification.
Cataract surgery costs are undiscounted. The Cataract Surgery Affordability Index (CSAI) is the cost of cataract surgery divided by the gross national income (GNI) per capita (2004, US$); lower numbers mean a higher affordability of surgery.

significantly influenced visual function; only ocular comorbidities—typically age-related macular degeneration—that existed before surgery or that developed after surgery had an influence. These results, therefore, tend to suggest that, provided normal postoperative complications are accounted for, cost-utilities are probably valid for the life span of the patient.

The second factor is the life expectancy of the patient. In the study of Busbee et al,[30] this figure was 12 years for their cohort, but only 5 years for the individuals in the investigation of Kobelt et al.[25] Obviously, if patients live longer, a higher number of QALYs can be expected and costs can be discounted over a longer period of time. Because life expectancy is still rising in most countries, it can be assumed that this factor will decrease the cost per QALY.

The third factor is the threshold visual acuity at which patients receive cataract surgery. An investigation that compared preoperative visual acuity in the United States, Canada, Denmark, and Spain found a significantly lower visual acuity (0.07) in Spain compared with the United States (0.23),[67] so in developed countries the threshold is likely to be lower than in developing countries. In addition, Kobelt et al[25] in commenting on their utility findings, note that many patients in Sweden are operated on automatically as soon as a certain level of visual impairment is reached, a mechanism that is not seen in developing countries, although it might be a feature of socialized medicine to some extent. The reason this factor is important is that the perceived benefit to the patient, however measured, will be less if the preoperative visual acuity in either eye is better.

Research has found that the improvement in visual acuity as a result of cataract surgery impacts utility values and in most instances can be correlated satisfactorily with health-related quality-of-life instruments or utility-measuring methods.[15,25,68–70] Further, the change in utility value perceived by the patient is correlated more positively with the better-seeing eye.[12,25] If the nonoperated eye is the better-seeing eye—which is usually the case for first eye operations—then the utility change perceived by the patient will be far less in comparison with the situation in which utility values are measured before and after cataract removal in both eyes. In addition, and this could also be key, generic health-related quality-of-life measures are sensitive only to visual acuity in the better-seeing eye, not the operated eye.[70] This could be one reason why the utility changes reported by Räsänen et al[32] are much smaller than those published by Busbee et al,[30] because the Finnish group used the semigeneric 15D instrument. However, Kobelt et al[25] noted in their study that other ocular comorbidities and diseases common to elderly patients can skew utility values, mak-

Table 4. Cost-Utility of Selected Medical Interventions

Intervention	Cost-Utility (US$/QALY)	Country	Reference	Remarks
Carpal tunnel syndrome surgery	(a) 140 (b) 282	United States	Chung et al[50]	(a) At age 55 years, (b) at age 65 years; utility values derived from experts; costs averaged from 2 different types of operation
Epileptic surgery	18 331	United States	Langfitt[51]	
	32 000	United States	King et al[52]	
	67 026	Switzerland	Tureczek et al[53]	Change in QOLIE-89 used for utility value (Wiebe et al[54]); 20-yr life expectancy
	3983	Colombia	(cost data)	
Hip arthroplasty	2279	Canada	Rorabeck et al[55]	Average of cemented/cementless costs; TTO utility data; 20-yr life expectancy
	2276	Finland	Rissanen et al[56] (cost data)	Utility data from Rorabeck et al[55]; 20-yr life expectancy
	2400	United Kingdom	Keating et al[57] (cost data)	Utility data from Rorabeck et al[55]; 20-yr life expectancy
	(a) 2531 (b) 4824	United States	Chang et al[58]	60-year-old white women; (a) cost of operation + rehabilitation; (b) lifetime costs; QALYs discounted 5%
	4474	United States	Bozic et al[59] (cost data)	Utility data from Rorabeck et al[55]; 20-yr life expectancy
Knee arthroplasty	12 720	Finland	Rissanen et al[56] (cost data)	Utility data from Donell et al[60]; 20-yr life expectancy
	10 618	Australia	Burns et al[61]	Utility data from Donell et al[60]; 20-yr life expectancy
	6535	Canada	(cost data)	
	8513	United Kingdom		
	6701	New Zealand		
	10 325	Sweden		
	14 603	United States		
Implantable defibrillator	(a) 7050 (b) 704	Senegal	Thiam et al[62] (cost data)	(a) Using TTO utility change (Lopez-Jimenez et al[63]) and 6-yr life expectancy; (b) using utility of 0.88×7.7-year life expectancy for MADIT I trial (Sanders et al[64]) lifetime costs not included (a and b)
	22 623	United States	Sanders et al[64]	QUALYs calculated using utility of 0.88×age-specific weight data (MADIT I trial); includes lifetime costs
	21 804	United States	Chan et al[65]	QUALYs calculated using utility of 0.88×age-specific weight data (MADIT II trial); includes lifetime costs

MADIT = Multicenter Automatic Defibrillator Implantation Trial; QALY = quality-adjusted life year; QOLIE-89 = 89-item Quality of Life in Epilepsy Inventory; TTO = time trade-off.
Costs have been converted to 2004 US dollars, and discounted 3%. All QUALYS are discounted 3% annually unless otherwise stated.

ing conclusions difficult to draw. This point also was highlighted by Räsänen et al,[32] because one third of their patients had secondary ophthalmic diagnoses, which might have reduced the perceived benefit of cataract surgery.

On the cost side of the cost-utility equation, we found that the methodology used by study authors varied substantially. In trying to make comparisons, therefore, we tried to standardize costs as much as possible. Nevertheless, it is likely that the costs reported here are lower than true costs, which would tend to underestimate the cost-utility of cataract surgery. For example, in Canada and many Western European countries in which socialized medicine operates, some fees are based on rates that governmental entities reimburse cataract surgery centers, rather than true market costs. Moreover, few costing mechanisms capture patient costs, which can be useful when attempting to estimate cost-utility from a societal perspective.

Costs also are impacted by the efficiency of the surgical center. Few studies have successfully measured the cost-effectiveness of surgery centers in such a way as to make meaningful comparisons. For example, Singh et al[71] compared the cost-effectiveness of cataract surgery between government camps, a nongovernmental hospital, and a state medical college functioning as a district hospital and found that based on units costs, and a simplified user-satisfaction scale, the nongovernmental hospital was by far the most cost-effective. However, because the different types of surgery were not separated out and because of the manner in which complications and patient satisfaction were handled, such results must be treated with circumspection. In contrast, Lundström et al[72] attempted a sophisticated approach to measuring both the output and efficiency of several cataract surgery centers in Sweden, using the Malmquist quantity index approach,[73] which factors in patient satisfaction (visual acuity and daily life activity changes, including the Catquest questionnaire), as well as costs and output of surgeries. In essence, it maps participating centers against the best possible results in terms of efficiency given a specific case mix of patients with or without an ocular comorbidity (output) and costs (input). The calculations are complicated, but the results can provide useful rankings in terms of cost-effectiveness that would not be captured with normal conventions.

In summary, there are several variables that affect the cost-utility calculation. The true cost-utilities for studies cited in Table 2 probably lie between the 2 different figures, depending in each instance on the life expectancy, ocular and other comorbidities present, whether one or both eyes are being operated on, the preoperative visual acuities of the eyes, and the true costs of the surgery and follow-up, including complications. Cost-utility is one measure of cost-effectiveness, but cannot be appreciated in isolation without knowledge of the affordability of the operation. For example, the cost-utility of first-eye cataract surgery in Nepal is between $20 and $170/QALY, but does this mean patients in Nepal will be able to afford the surgery? The results of our CSAI suggest that affordability will be on a par with that of the United States, but by contrast, in India, the operation is considerably more affordable.

How cost-effective is cataract surgery when benchmarked against other comparable medical interventions? In developed countries, such as the United States, interventions that cost less than US$100 000/QALY gained have been considered cost-effective,[74] with those less than or US$20 000/QALY being considered especially cost-effective. Other researchers have suggested a value of US$50 000/QALY as a benchmark for the threshold of non–cost-effective interventions.[75,76] In an undeveloped country, what is considered to be a cost-effective intervention is far less; a figure of US$150/DALY averted has been suggested.[77]

If we compare the cost-utility of cataract surgery in various countries against the cost-utility of medical interventions listed in Table 4, it can be seen that in the United States, depending on what method is used to calculate the cost-utility of cataract surgery, cataract surgery is not more cost-effective than hip arthroplasty, but is probably more cost-effective than knee arthroplasty, epileptic surgery, or having a defibrillator implanted for cardiac dysfunction. In developing countries, data for these medical interventions is scant, but the cost-effectiveness of cataract surgery seems to be of the same order as for developed countries when other interventions are compared.

Cataract surgery in the Western world, with a range of $245 to $20 000/QALY gained, is a cost-effective procedure by any measure. In developing countries, where absolute cost-effectiveness measures have less meaning, the cost-utility figures we calculated suggest that the procedure is cost-effective and relatively affordable when compared with the costs of the procedure in the United States.

The challenge for the future will be to determine which utility instruments best capture the quality-of-life issues for patients. At present there is little agreement on which instrument to use and whether cost-effectiveness of cataract surgery is best represented by operation on the first eye, or both. There will always be heterogeneity when comparing populations from different countries—for example, life expectancy and differing preoperative visual acuities—but if ophthalmologists can agree on a set of standards, perhaps modeled from existing data, then cost-utility can be judged better and the figures defined better.

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