Review Article

Health economics and manual small-incision cataract surgery: An illustrative mini review

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Cataract extraction is one of the most common surgical procedures performed worldwide. Manual small-incision cataract surgery (MSICS) is a popular technique of cataract extraction. Full economic evaluation of different techniques is of value to policy makers. This was a systematic review of published literature to present a brief overview of evidence available in respect of economic evaluation measures like cost effectiveness, cost utility, and cost parameters in cataract patients regarding MSICS. The data on these was sparse and heterogeneous. Direct costs of MSICS were lower than phacoemulsification (PE): $25.55 (PE) to $17.03 (MSICS) in India, $15 (MSICS) to $70 (PE) in Nepal, and $62.25 (MSICS) to $104.15 (PE) in Thailand. The cost utility analysis for MSICS demonstrated savings of $79.57 (INR6175) per gain in LogMAR BCVA, $8.91 (INR691) per QALY gained and $1.42 (INR110) per VF 14 score increment in India. Incremental cost-effectiveness ratio (ICER) $368.20 (13,215.50 Baht) for MSICS was better than $489.30 (17,561.70 Baht) for PE in Thailand. ICER for femto laser-assisted cataract surgery (FLACS) compared to was €10,703 in femtosecond laser-assisted versus phacoemulsification cataract surgery (FEMCAT) study. The corrected ICER for PE against MSICS is €146.50. The limited data available demonstrates that MSICS is the most cost-effective technique among FLACS, PE, and MSICS. MSICS scores over other existing alternatives of cataract extraction from cost-effectiveness and cost-minimization approaches. Further research is required in this area.

Key words: Cost-effectiveness analysis (CEA), cost-utility analysis (CUA), health economics, incremental cost-effectiveness ratio (ICER), manual small-incision cataract surgery (MSICS)

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Cataract is a major cause of preventable global blindness. After uncorrected refractive error, it is the second cause of moderate or severe visual impairment (MSVI <6/18).[1] It is treated by extracapsular cataract extraction intraocular lens (ECCE-IOL), phacoemulsification (PE), manual small-incision cataract surgery (MSICS), and femto laser-assisted cataract surgery (FLACS) among other procedures. Approximately 17.7 million phacoemulsification procedures were performed in 2018, and the Cataract Surgery Devices Market expected to grow with a CAGR of 4.2% from 2022 to 2027.[2] Perioperative complications can affect 4.2%–8.6% of all surgeries performed and may be associated with a worse postoperative visual outcome.[3,4] Most studies have studied the clinical outcomes of MSICS and compared it with other techniques. Economic evaluation is a comparative analysis of costs and outcomes of different alternatives. Drummond *et al*.[5] described six categories of economic evaluation: outcome description, cost description, cost-outcome description, efficacy or effectiveness analysis, cost analysis, and full economic evaluation as shown in Fig. 1. The latter three can be used to compare different techniques or alternatives.

Full economic evaluation measures both costs and outcomes of compared alternatives. The cost is measured in monetary units while the outcome component measurement can vary. On the basis of outcome measurements, the full economic evaluation can be of the following types as shown in Table 1: cost–benefit analysis (CBA), cost-minimization analysis (CMA), cost-effectiveness analysis (CEA), cost–consequence analysis (CCA), and cost–utility analysis (CUA).[5] The National Institute for Health and Clinical Excellence (NICE) had recommended CEA and CUA over others due to technique limitations in CBA and CMA since clinical effectiveness measurement is usual in healthcare.[6]

The recent femtosecond laser-assisted versus phacoemulsification cataract surgery (FEMCAT) by Schweitzer *et al*.,[7] which was a multicenter masked randomized superiority and cost-effectiveness, trial has sharply shifted the focus on to the commercial and health economics aspects of the methods of cataract extraction. Very few studies are available on the costing

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and economic aspects of MSICS and the need to map out the known and unknown areas therefore arises for this method.

We decided to study economic evaluation measures like cost effectiveness, cost utility, and cost parameters in cataract patients who underwent cataract extraction by MSICS in comparison to the gold standard phacoemulsification in randomized controlled trials and observational real-world data in publications in indexed journals.

This systematic review compared MSICS and phacoemulsification. Ethics Board Approval was not required because secondary data was used which consisted of reviewing published manuscripts which had Institution Ethics Board Approvals. Heterogenous data sources including NHS Economic Evaluation Database, Health Technology Assessment Database, Scopus, Embase, Medline, PubMed and Cochrane databases were searched using the keywords mentioned in supplementary materials.

Duplicate entries were removed electronically. If English translations were available, then non-English studies were included, but no contact with any author was made for this purpose or otherwise. Two hundred twenty-six studies were screened manually and 32 studies were found to be eligible for inclusion in the review. The decision to carry out detailed meta-analysis was left to availability of adequate high-class evidence to draw useful conclusions failing which a narrative review was to be performed. Hand searching of articles from reference lists of obtained articles was also done by OB. Data was sought on cost, incremental cost, effectiveness, utility, and incremental cost-effectiveness ratio (ICER) along with any surrogate descriptors or markers used in full economic analysis. Two assessors JB and OB after doing a pilot validation on 5 studies to check consistency of assessment made the bias tables. The consensus decision was valid. In case of a stalemate or tie, the tiebreaker was adjudicated by AS who was blinded to the selection of JB and OB. Only reasons, if any were given, from assessments of raters were provided to AS for adjudication of tie break. The list of citations included is given in the supplementary material.

Figure 1: Six categories of economic evaluation

Heterogeneity was assessed by calculating I^2 for quantifying inconsistency if the study designs were similar:

$$I^2 = \left(\frac{Q - \mathrm{df}}{Q}\right) \times 100\%$$

In this equation, Q is the χ^2 statistic and df is its degrees of freedom. Thresholds for the interpretation of the I^2 statistic were specified as follows: 0% to 35% as not important; 35% to 60% as moderate heterogeneity; 60% to 90% as substantial heterogeneity; 75% to 100% as considerable heterogeneity. Since heterogeneity depends on many factors, the latter two would depend on other value judgments also. In case of substantial or considerable heterogeneity, the authors would not be calculating summary forest plot. Standardized mean difference (SMD) with 95% CI for continuous variables like cost, ICER, etc., was to be employed if the studies were comparable in design after statistical heterogeneity evaluation by I^2 statistic. A randomeffects metaanalysis by DerSimonian–Laird method was to be employed if the samples were large. However, the literature showed a paucity of comparable data on MSICS.[8]

Results

A total of 226 studies were screened and 32 were selected as shown in Table 2.

Discussion

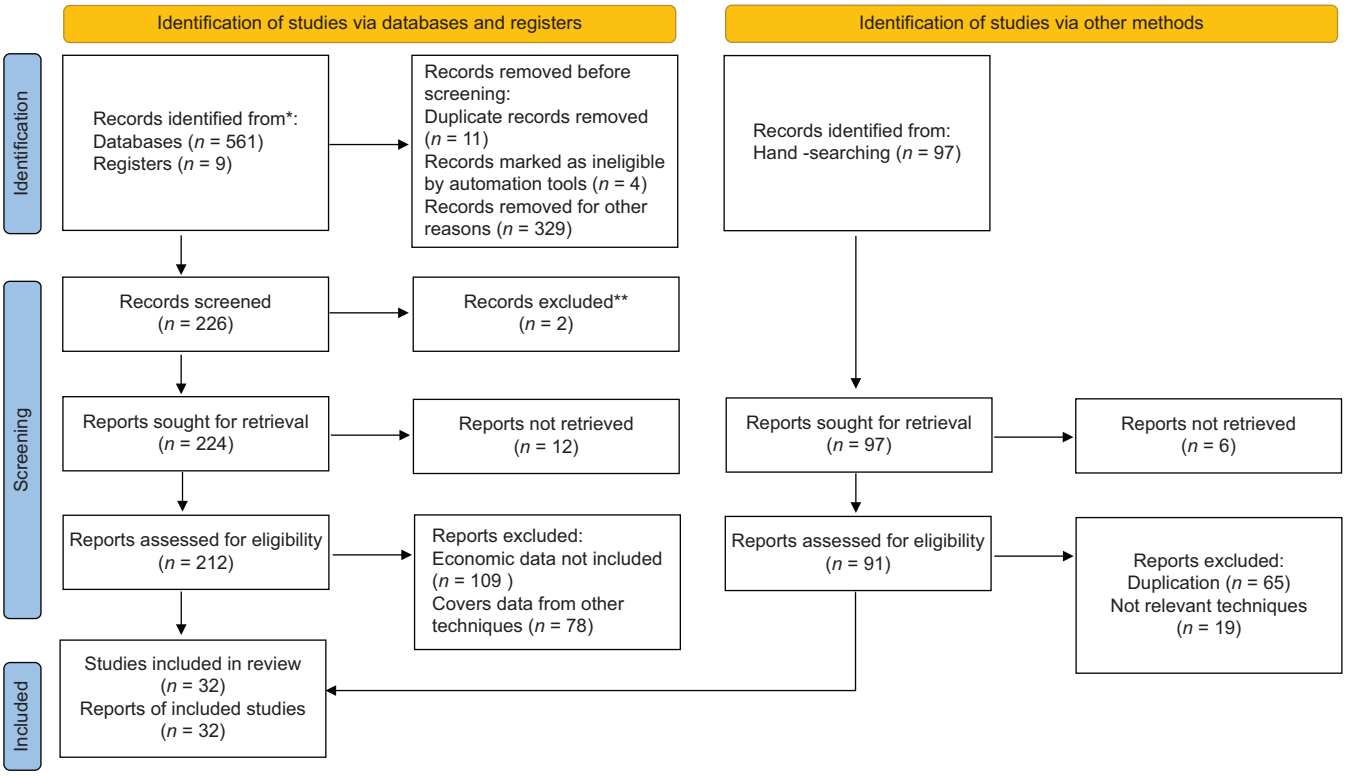
The Cochrane systematic review demonstrated that MSICS gave better uncorrected visual acuity and less surgically induced astigmatism compared to ECCE, but the quality of evidence was low.[9] Similarly, comparing phacoemulsification with MSICS the review found that there were no differences in terms of visual outcome between these two interventions at 6 and 12 months follow-up, but information on vision-related quality of life and cost utility was not easily available.[10]

Costs of cataract surgery are divided into fixed costs and overheads or variable costs. The fixed costs are those spent on

Table 1: Full Economic Evaluation Techniques in Healthcare

Full Economic Evaluation Techniques in Healthcare	
Cost-Minimization Analysis (CMA)	Determines the least costly intervention among alternatives that are assumed to produce equivalent outcomes.
Cost–Benefit Analysis (CBA)	Compares costs and benefits quantified in common monetary terms
Cost-Effectiveness Analysis (CEA)	Compares costs in monetary units with outcomes in quantitative non-monetary units.
Cost–Utility Analysis (CUA)	Compares costs in monetary units with outcomes in utility to the patient measured in QALY, DALY, etc., A type of cost-effectiveness analysis.
Cost–Consequence Analysis (CCA)	Presents costs and outcomes in discrete categories without aggregating or weighting them

Table 2: Flow diagram of review



buildings (sunk costs) and machines, etc., (capital expenditure). These remain unchanged over medium term and are clubbed under capital (C) costs in analysis. The variable costs are called overheads or can be divided into labor (L) and material (M) costs. Labor costs include salary, welfare, medical fee, training fee, and other fees for all workers working directly in the facility. The average labor cost/case uses the expenditure on OPD, IPD, OT, ophthalmologists, and supporting healthcare personnel.[11] Material costs are the costs of materials and public utilities expended in the OPD, ward, operation theater including medical supplies used, medicine for cataract patients after surgery, etc. The calculation of material costs is limited to those expended directly on these cataract cases. If hospitalization is used, then the costs are added to the material costs.[11]

Experience of Ruit *et al*., Muralikrishnan *et al*., and Gogate *et al*. shows that use of locally manufactured IOLs, viscoelastics, and pharmaceuticals dramatically lowered the costs as the locally made PMMA lenses could be as low as $1.44.[12–15] The foldable lenses manufactured in India are also now available at a fraction of the cost with some IOLs costing one-tenth of the price of those imported from the United States.[15] Gogate *et al*. in their single-masked randomized controlled clinical trial with four surgeons conducting a total of 200 surgeries each of phacoemulsification and MSICS reported that PE costing US $69.40 was more expensive than MSICS at US $38.95.[12] The surgeons reused some consumables and brought the costs for PE down to US $42 while MSICS costed US $15. Fixed facility costs in this study included the phacoemulsification machine. They were added to the costs of consumables and the cost of the procedure as calculated taking the average of the expenditure. The fixed facility cost was $10, and the resultant cost therefore was about $49.40 for PE and $28.95 for MSICS. With reuse of some consumables, the adjusted cost difference was $32 for PE to $5 for MSICS as seen in Table 3.[13] Malik *et al*.[16] reported that the cost of rigid PMMA IOL implants with MSICS lenses was cheaper than PE with rigid PMMA lenses as well as phaco with foldable lenses. The major limitation of this study was the costing procedure not being similar to other studies. Thus, only the trends can be used.

Hennig *et al*.[17] from Lahan, Nepal, in their large 8955 patient study reported that PE was more expensive than MSICS. The consumables cost was US $4.28 per operation for PE. The cost of the rigid IOL for 8410 patients was $1.94 while it was US $16.50 for 545 patients receiving foldable IOL. The cost of consumables per cataract operation including IOL, all medicines used before, during and after surgery, anesthesia, viscoelastics, irrigation solution, disinfectants, and eye pads was approximately US $6.50 at 2001 rates. The high import content shifted the cost of surgery by PE upwards. In developing countries, the locally made IOLs have been available for less than three pounds (GBP) while the lens in the western world was priced at about ≤38.00 (GBP).[18] Minassian *et al*.[18] had reported that the cost of PE surgery was less costly compared to conventional methods in Europe but he failed to take the capital cost of the PE machine into account. Muralikrishna *et al*.[14] used a "micro-costing approach" to report on the three procedures: PE, MSICS and ECCE-IOL. The patient's direct and indirect costs for each procedure were calculated by interviewing staff and patients. They used assumptions about prices for relevant cost items such as transportation, food, medicine, spectacles, and economic productivity loss. Averaged out costs showed that provider's direct costs were highest for PE (US $25.55), followed

Table 3: Cost Analysis in Cataract Extraction

	Study	ECCE-IOL	PE	SICS
India	Gogate *et al*.[12]	US $15.82		US $15.68
India	Gogate *et al*.[13]		US $42.10	US $15.34
India	Muralikrishnan *et al*.[14]	US $16.25	US $25.55	US $17.03
Nepal	Ruit *et al*.[15]		US $70	US $15
Thailand	Jongsareejit *et al*.[11]		US $104.15 (3738.19 Baht)	US $62.25 (2234.38 Baht)

by MSICS ($17.03) and ECCE-IOL ($16.25). Average direct and indirect patient costs were highest for ECCE-IOL ($19.85), while the costs for PE and MSICS were identical ($12.37). ECCE-IOL had the highest total costs and MSICS had the lowest total costs from the societal perspective, with PE occupying the intermediate position. Each procedure is suitable for certain situations and the procedures per se cannot be compared from the operational viewpoint in that situation.

The capital costs need to be amortized over the lifecycle of the product machines, the annual maintenance costs for devices, depreciation cost for the medical devices, and the buildings. Such investments can vary temporally, and price factor correction as well as purchasing power parity are desirable but not possible. The capital investment on the PE machine was ≤35,000 in 1992 according to Rosenthal *et al*. which had risen to US $70,000 for AMO Whitestar used by Ruit *et al*. in their 2007 study.[15,19] The difference in instrumentation in Ruit's case can be gauged from high-end operating microscope at US $52,000 for PE to Zeiss 1 FR operating microscope at US $9,200 for MSICS.[15] It is not possible for real-world data to differentiate the microscopes and instruments because after installation they are used as a continuum between different surgeons.

Surrogate costing measures like the billing cost by the private secondary-care provider with direct patient and insurance payouts can be used as billed-in cost with the assumption that sustainable costs have been levied. However, a bias creeps in as there is no scope of judging the upward marking of prices to include reasonable return on investment and if included then the quantum of discounted net present value of such returns.[11,20,21] Therefore, secondary data based studies were placed separately and heterogeneity of studies obviates the use of a narrative review. The societal costs for PE include the requirement for a stable electric power supply and centers which can absorb the costs of the machine and its annual maintenance costs. MSICS, on the other hand, was found to be feasible in smaller cost setups with even a small generator providing the power. The disposables and consumables, though similar, include things like PE needles (some manufacturers) tubing, cassettes, etc., for the phacoemulsification machine.[11,13,14,17,20,21]

Brown *et al*. and Lansingh *et al*. determined the utility for cataract surgery of the better seeing eye using HRQoL.[22,23] They reported that utility $y = -0.04792x^3 + 0.191x^2 - 0.4233x + 0.9128$ where x = Visual Acuity in Log MAR units. This utility analysis can be modified for the worse eye by using a weighting factor of 0.3, as reported by Scanlon *et al*.[24] Khan A *et al*.[25] reported that there were no significant difference in effectiveness between PE and MSICS on utility parameters as shown in Table 4.

However, the cost utility scores for these parameters showed significant differences between PE and MSICS. The cost-utility difference was significantly better for MSICS compared to PE as shown in Table 5. Thus the two comparison measures, utility and cost-utility ratio, need to be differentiated from each other as illustrated in the two tables.

Cost-effectiveness and cost utilization analysis are important tools for decision-making for healthcare providers and policymakers. Incremental cost effectiveness ratio (ICER) is a popular measure of cost-effectiveness or marginal utility of the approaches under study. ICER is a measure of the additional cost incurred when choosing the less effective intervention against the more effective one to achieve 1 unit of effectiveness. It is measured as

$$\text{ICER} = \frac{\text{Cost A - Cost B}}{\text{Effectiveness A - Effectiveness B}}$$

A = Current Gold Standard

B = The intervention under study

Effectiveness in cataract surgery can be visual acuity, quality of life, complications, and astigmatism beyond a particular level. For the purpose of this review, we focused on the visual acuity and complications. If there is a significant difference between alternatives then the cost minimization approach will fail. The difference in effectiveness needs to be adjusted using suitable equalization methods and approaches like quality of life, disability-adjusted life years (DALYs), and quality-adjusted life years (QALYa) become important. Broadly, DALY measures health loss in the quality of life while QALY measures the same quality of life in health gain. Using a purchasing power parity principle for the country the per capita gross national product can be used for standardization. The quality-adjusted life year (QALY) is an outcome measure that expresses the duration and quality of life. It is the main pillar of cost-effectiveness analyses. Early rehabilitation favours better QALY values and decision makers have frequently used the World Health Organization (WHO) benchmark based upon a country's gross domestic product (GDP) per capita with services exceeding three times GDP per capita being considered economically unattractive.[26] There was no statistically significant difference in VA gain or complication rate between MSICS and phacoemulsification in most studies.[11–15]

Traditionally lower astigmatism and faster recovery in favour of phacoemulsification as compared to manual small-incision cataract surgery has been reported by many authors. The difference, however, was not carried forward at three-month meta-analysis.[21] A mild myopic error induced by incision modification in MSICS can enable spectacle independence in resource constrained environments.

Table 4: Utility Difference Between Phacoemulsification and MSICS[25]

Parameter	Mean Change	95% CI	*P*
LogMAR BCVA	0.03	−0.05 to 0.11	0.46
Change in QALYs	1.14	−0.89 to 3.16	0.26
Change in VF14 score	7.92	−1.03 to 16.86	0.08

Legend: LogMAR-Logarithm of the minimum angle of resolution is a measure of visual acuity. QALY-Quality-adjusted life-year (QALY) is a measure of the value of health outcomes. VF-14 score-Visual function index (VF-14) is a brief questionnaire designed to assess visual function impairment and generate an aggregate score (AS) between 0 and 100.

Table 5: Cost-Utility Ratio Difference Between Phacoemulsification and MSICS

Parameter	Mean Change	95% CI	*P*
Cost per gain in LogMAR BCVA	−6175	−8375 to-3975	<0.001
Cost per QALY gained	−691	−1363 to-18	0.04
Cost per VF14 score increment	−110	−194 to-26	0.01

Legend: LogMAR-Logarithm of the minimum angle of resolution is a measure of the visual acuity. QALY-Quality-adjusted life-year (QALY) is a measure of the value of health outcomes. VF-14 score-Visual function index (VF-14) is a brief questionnaire designed to assess visual function impairment and generate an aggregate score (AS) between 0 and 100

Table 6: Astigmatism Comparison between Phacoemulsification and MSICS

Author/ Study	Technique	Number of subjects	Mean Surgically Induced Astigmatism (in Diopters)	SD (in Diopters)
Gogate[11]	PE	85	1.1	0.9
	MSICS	187	1.2	1.1
Venkatesh[27]	PE	113	0.8	0.24
	MSICS	117	1.2	0.36
Goel[28]	PE	30	0.58	0.43
	MSICS	30	0.95	0.48
George[29]	PE	60	1.38	0.77
	MSICS	53	1.5	0.77

Legends: PE-Phacoemulsification. MSICS-Manual small-incision cataract surgery

Table 7: Incremental Cost-Effectiveness Ratio (ICER) Difference Between Phacoemulsification and MSICS

	MSICS	PE
Effectiveness	0.76	0.66
Cost (Baht)	10,043.81 Baht, US $265.73, ≤135.51 and 911.77 RM (Malaysian Ringgit) per case	11,590.72, US $318.38, ≤162.35 and 1092.40 RM per case
CE ratio	US $368.20 (13,215.50 Baht)	US $489.30 (17,561.70 Baht)

According to the study by Jongsareejit *et al*.,[11] there were no differences in the outcomes of visual acuity, astigmatism, and complications between phacoemulsification and MSICS in the three-month follow-up [Tables 4-6]. The cost-effectiveness ratio for MSICS was 13,215.50 compared to PE (CE ratio = 17,561.70) [Table 7]. However, the cost differential component in this study was uncharacteristically low with 10,043.81 Baht/case ($280) for MSICS and 11,590.72 Baht/case ($323) for phacoemulsification. This represented a saving of 1550 Baht ($43).[11] Gogate *et al*. and Muralikrishnan *et al*. reported that MSICS provider's direct costs were (US $15.68, US $17.03).[13,14] The pricing in India compared to even Thailand is interesting where this surgery costs nearly $300. In the UK, the total cost of PE was ≤359.89 with the postoperative care, and additional spectacle cost included in the costing by Jongsareejit *et al*.[11] estimated savings of about 290 million Baht (USD8.08 million) for Thailand if all 1.36 lakh cases were to receive MSICS at cost of about approximately 1790 million Baht (USD49.87 million) against 2080 million Baht (USD57.95 million) required or PE. FEMCAT study reported an incremental cost-effectiveness ratio of €10703 saved per additional patient who had treatment success with PE compared with FLACS, while incremental cost-effectiveness ratio who experienced success with MSICS represented a saving of US $121.10 in 2012 which is the equivalent of $152.51 in 2022 at cumulative price increase of 25.92% to adjust for inflation.[7,29,30] This ICER of US $152.51 at current exchange value is €146.50. Hence MSICS is the most cost-effective technique among the three by interpolation. However, there is a paucity of high-quality data for economic analysis of cataract extraction techniques and more work is required on this subject. These findings have a bearing on the allocative decisions in healthcare policy, especially in public health and government-funded projects.

Conclusion

Inadequate high quality costing data was obtainable for drawing clear inferences. The limited data available supports the contention that, from societal perspective, MSICS has the least costs followed by PE, ECCE-IOL, and FLACS. Heterogeneity among studies is very high. There have been very few robust studies to address the key questions of incremental cost-effectiveness ratio, cost, incremental cost, effectiveness, and utility for MSICS. The framework for cost analysis needs to amortize the costs over the lifespan of the machine while calculating costs. The authors recommend use of CUA and CEA over other techniques in the Indian setting, even though there is controversy over determination of quality-adjusted outcomes when data and resources are available. CEA can be inferred from CUA data theoretically, but CEA is useful when only intermediate outcomes of the compared alternatives are available. Future research in this area will be useful for allocative and technical efficiency measurements in policymaking.

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Conflicts of interest

There are no conflicts of interest.

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Supplementary Materials

Manual small incision cataract surgery (300)

small incision cataract surgery (1,341)

Economics/ (1,104,139)

Costs and Cost Analysis (273,004)

exp Economics, Hospital/ (140,387)

exp Economics, Medical/ (167,192)

Health Budgets/ (24,158)

Healthcare Budgets (12,839)

exp Models, Economic (51,904)

Health economics (1,715,982)

quality of life.tw. (149495)

Value of Life (5495)

Quality-Adjusted Life Years (7808)

quality adjusted life.tw. (6579)

disability adjusted life.tw. (1361)

Manual small incision cataract surgery (226)

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