ORIGINAL ARTICLE

# A Cost-benefit Analysis of 2018 Cataract Surgery in the United States

**Gary C. Brown[1,2,3,4], Melissa M. Brown[1,2,3,4], Brandon G. Busbee[5], Sara B. Rapuano[1,3]**

*[1]Center for Value-Based Medicine, Hilton Head, South Carolina, [2]Wills Eye Hospital, Philadelphia, PA, [3]Department of Ophthalmology, Jefferson Medical University, Philadelphia, PA, [4]Emory University School of Medicine, Atlanta, GA, [5]Tennessee Retina, Nashville, TN*

## ABSTRACT

**Background:** Cost-utility analysis was performed by our group on conventional Medicare beneficiaries in the U.S. in 2012, 2000, and 1985. We are unaware, however, of a formal cost-benefit analysis, performed for U.S. cataract surgery. The authors, therefore, undertook a cost-benefit analysis to ascertain the financial monetary benefits returned to society from the surgery versus the direct medical costs expended on it from both the individual and macroeconomic perspectives. **Methods:** The 14-year, cost-benefit model utilized a societal cost perspective and employed 2018 U.S. real dollars and Patient Outcomes Research Team study vision outcomes. Expenses included average national Medicare Fee Schedule costs, while financial benefits or costs returned to society by surgery included ophthalmic and non-ophthalmic direct medical costs, caregiver costs, and productivity costs. Other outcomes included (1) average national Medicare Fee Schedule costs, (2) overall Medicare costs, (3) Medicaid costs, (4) commercial insurer costs, (5) patient costs, and (6) macroeconomic costs and return-on-investment (ROI) for each. Net present value analysis discounted outcomes and costs at 3%/year. The number of cataract operations in the conventional Medicare population 2018 were assumed to be similar to those in 2017. **Results:** Individual patient costs: The direct medical cost of each cataract surgery was $2,526, with a 14-year, societal financial gain of $372,543 for first-eye surgery. This yielded a 14-year ROI of 14,648% (42.9% annual interest rate) and a societal ROI of $147.48 for $1 expended on first-eye surgery. Direct ophthalmic medical costs: First-eye, 2018, cataract surgery/surgeon costs were $2,526/$656, 14.4%/25.0% less than in 2012, 43.3%/51.9% less than in 2000, and 87.9%/92.5% less than in 1985. The 2018 surgeon fee was 7.5% of the 1985 fee. Macroeconomic costs: A 2018 conventional Medicare patient cohort model had 1,907,318 patients undergoing 3,337,807 cataract operations with a direct medical cost of $8.43 billion. The 14-year societal, monetary ROI was $710.6 billion, an 8,428% ROI per patient. The 14-year gross domestic product contribution was $170 billion. **Conclusions:** 2018 cataract surgery delivers great financial value. The total Medicare-approved reimbursement is 12.1% of that in 1985, while the surgeon reimbursement is 7.5% of that in 1985. Cataract surgery returns considerable financial resources to patients and health insurers and increases the U.S. national wealth.

**Key words:** Cataract surgery, cost-benefit analysis, financial return-on-investment

## INTRODUCTION

In 2018, 3,337,807 cataract extraction and intraocular lens implantation (cataract surgery) procedures (current procedural terminology [CPT] code 66984) were performed on conventional Medicare beneficiaries.[1] The intervention ranked #5 in allowable physician level 1 CPT Medicare charges behind codes for medical office visits and hospital inpatient visits. Cataract surgery is the most common surgical procedure performed on Medicare patients in the United States.[1]

The United States National Cataract Patient Outcomes Research Team (PORT) reported U.S. cataract surgery outcomes in 1994.[2] The mean pre-operative cataract vision was Snellen 20/83, and the mean post-operative vision was Snellen 20/27.[2] The Royal College of

**Address for correspondence:**
Gary C. Brown, Center for Value-Based Medicine®, Box 3417, Hilton Head, SC 29928, 215-353-6248.
E-mail: gbrown@valuebasedmedicine.com

**Table 1:** Value-based medicine® cost-benefit analysis features

| |
|---|
| Clinical features of the U.S. Cohort of the PORT study,[2] Confirmed by The Royal College of Ophthalmologists' National Ophthalmology Database study of cataract surgery[3] |
| Inclusion criteria. Age>50 years in person requiring cataract extraction and intraocular lens implantation for functional help *n*=722 from 75 U.S. Centers[2], and *n*=127,685 patients from 28 UK Trusts[3] |
| Mean age at study entrance: 73 years |
| Mean life expectancy: 14 years[6] |
| Mean pre-operative vision: 20/83[2] |
| Mean post-operative mean vision: 20/27[2] |
| 4-month follow-up; LOCF to 14 years |
| Cost-benefit model parameters |
| Financial value-based outcomes associated with cataract surgery include: |
| Financial value in the form of cost-utility ratio = $/QALY (dollars expended per QALY gained) |
| Financial value in the form of ROI or cost-benefit ratio=the societal monetary ROI for the dollars expended to improve vision with first-eye cataract surgery |
| Both outcomes are discounted at 3% annually with NPV analysis[7] |
| The initial eye undergoing cataract surgery is that with the best vision |
| Adverse events (retinal detachment, endophthalmitis, opacified posterior capsule, corneal edema, and so forth) are as previously listed.[6] Adverse event QALY decrements and adverse event costs are integrated into all analyses |
| A societal cost perspective is performed as was the case in our 2000 cataract surgery analysis[4] and 2012 cataract surgery analysis.[5] |
| Direct medical cost (ophthalmic and non-ophthalmic) basis: National, average, 2018 Medicare Fee Schedule[8,10] |
| Direct non-medical (caregiver) cost basis.[9,11] |
| Indirect medical cost (productivity or salary loss) basis.[12-15] |
| NPV analysis used to discount all patient value and cost outcomes at 3% annually[7] |
| A control cohort comprised of the natural history of vision deterioration, starting with 20/83 vision, due to progression of cataract without surgery, was compared to the results of 2018 cataract surgery.[6] |
| First-eye cataract surgery negates the 1.0-year length of life loss associated with cataracts and 20/83 vision.[6,16] |
| For second-eye cataract surgery, the percentage of patient value gain and QOL gain is equal since there is no change in length of life conferred by second-eye surgery. There are, therefore, no additional societal costs accrued against the ophthalmic direct medical cost of cataract surgery with second-eye surgery |

LOCF: Last observation carried forward, QALY: Quality-adjusted life-year, ROI: Return-on-investment, NPV: Net present value, QOL: Quality-of-life

Ophthalmologists' National Ophthalmology Database study of phacoemulsification surgery reported in 2015 confirmed the PORT study vision outcomes.[3] These data on 180,114 eyes noted a mean pre-operative vision of Snellen 20/84 and mean post-operative vision of Snellen 20/29, virtually identical to the PORT study results. This suggests that cataract surgery results have remained excellent and unchanged over the past two decades.

We performed patient preference-based, cost-utility analyses on cataract surgery in 2000[4] and 2012.[5] More recently, we performed a 2018 cost-utility analysis, demonstrating that first-eye cataract surgery delivers a remarkable 33.3% patient value (improvement in quality-of-life [QOL] and/or length of life) gain over 14 years.[6]

At the same time that cataract surgery conferred great patient value gain, it returned a net $372,544 per patient to society for the $2,526 ophthalmic direct cost of first-eye cataract surgery expended. Our companion manuscript[6] addresses the costs of 2018 cataract surgery in a cost-utility analysis. The ophthalmic direct medical costs of cataract surgery expended and the societal financial return-on-investment (ROI) for these cataract surgery costs are assessed from individual and macroeconomic perspectives. No Medicare Advantage (Part C Medicare) data were utilized herein.

## METHODS

Cost-utility analysis quantifies the dollars expended for an intervention per quality-adjusted life-year (QALY) gained from the intervention, the latter a measure of the improvement in QOL and/or length of life, or patient (human) value gain conferred by the intervention.[7] Cost-benefit analysis, the form of healthcare economic analysis performed herein, quantifies the dollars expended for an intervention (investment) with those returned from the intervention (investment).[7] In essence, it compares the monetary value of the interventional costs with the monetary value of the benefits. In business, it is often used as a tool to provide a basis for comparing investment decisions.

We consider the financial value associated with interventions to be represented by: (1) The cost-utility ratio (CUR) and (2) the financial value gain or monetary ROI to society for the direct medical costs expended for an intervention.

**Table 2:** Ophthalmic direct medical costs associated with cataract Surgery in U.S. 2018 Nominal and Real Dollars

| Cost | CPT (level I HCPCS) code[1] | 1985 U.S. nominal $ for 1985 analysis | 2000 U.S. nominal $ for 2000 analysis | 2012 U.S. nominal dollars for 2012 analysis | 2018 nominal dollars, the cataract surgery costs utilized herein | 2018 U.S. real dollars, adjusted from 2012 nominal dollars using the Medical Care component of the CPI[17] | 2018 U.S. real dollars adjusted from 2000 nominal dollars using the Medical Care component of the CPI[17] |
|---|---|---|---|---|---|---|---|
| Eye examination, new patient[8] | 92004 | Unk | 144 | 145 | 154 | 171 | 236 |
| Surgeon fee[8] | 66984 | 2000 | 748 | 761 | 656 | 897 | 1224 |
| ASC fee[18] | NA | Unk | 928 | 853 | 992 | 1006 | 1518 |
| A-scan ultra- sonography[8] | 76519 | Unk | 79 | 82 | 76 | 97 | 129 |
| Topical antibiotic[6,*] | NA | Unk | 54 | 62 | 18 | 73 | 88 |
| Anesthesia[19] | NA | Unk | 360 | 428 | 355 | 505 | 589 |
| Adverse events[4,6,8] | Multiple | Unk | 212 | 223 | 259 | 263 | 347 |
| Total costs (one eye) | NA | 4,782 | 2,526 | 2,653 | 2,526 | 3,128 | 4,131 |
| Total costs (two eyes) | NA | 9,420 | 5,052 | 5,260 | 5,052 | 6,201 | 8,026 |

*Pricing obtained from the average of three major pharmacy chains (CVS, Walgreens, and Walmart) for topical dexamethasone, neomycin sulfate, and polymyxin b sulfate ointment; from GoodRx on the Internet @ https://www.goodrx.com/maxitrol?drug-name=maxitrol&form=eye-dropper&dosage=5ml&quantity=&days_supply=&label_override=neomycin%20%2F%20polymyxin%20b%20%2F%20dexamethasone, accessed August 31, 2018, CPT: Current procedural terminology, CPI: Consumer price index, ASC: Ambulatory surgery center, NA: Not applicable, HCPCS: Health-care Common Procedure Coding System, Unk: Unknown

Cost-benefit analysis does not quantify patient value gain but is related to it, in that the greater the improvement in vision from cataract surgery, the greater the patient value gain and the greater the cost-benefit ratio, or dollars returned to society for the direct medical costs of cataract surgery expended. We list the ophthalmic direct medical costs of cataract surgery herein as those occurring within 4 months after cataract surgery, while the societal costs returned as a result of the surgery occur over the 14-year life expectancy of the average cataract surgery patient.[6]

Our parameters for the cost-benefit analysis herein are the same as for the base case cost-utility model in our companion paper.[6] The 14-year time frame of the model is the same as the average life expectancy for the base case patient, a 73-year-old person undergoing cataract surgery.[6] The 2018 ophthalmic direct medical costs of cataract surgery and low vision aids are 4-month costs expressed in 2018 U.S. nominal dollars, while other societal costs are 14-year costs denominated in 2018 U.S. real dollars adjusted for the time value of money. Cataract surgery for the base case, which improves mean vision in the better-seeing eye from a pre-operative 20/83 to post-operative 20/27, also prevents the loss of a year of life otherwise associated with 20/83 baseline vision in the 14-year model.[6] The parameters utilized in our cost-benefit model are listed in Table 1.

## Direct medical costs

Cataract surgery costs are considered as positive costs, while all costs accruing against the costs of cataract surgery are considered negative costs. The 2018 ophthalmic direct medical costs include those expended for cataract surgery. They total $2,526 for unilateral cataract surgery and $5,052 for bilateral cataract surgery, both in 2018 U.S. nominal dollars.[6] These costs are taken from the 2018 average, national Medicare Fee Schedule [Tables 2 and 3].[8] The other ophthalmic direct medical cost we assessed was that for low vision services,[9] a −$2,238 cost that accrued against the ophthalmic direct medical costs of first-eye cataract surgery in the 1st year. The slow rate of cataract progression obviates a frequent change in lens correction or a low vision device.[6] The non-ophthalmic direct medical costs [Table 3] are those made unnecessary by first-eye cataract surgery. They include 14-year costs precluded by better vision decreasing: (1) depression, (2) trauma, (3) subacute nursing facility admissions, (4) as yet unidentified Medicare interventions, and (5) nursing home costs.[10] The non-ophthalmic direct medical costs accruing against the direct cataract surgery costs totaled −$67,817.[6]

## Direct non-medical costs

Alternatively known as caregiver costs, the direct non-medical costs include those associated with (1) residence/residence change, (2) transportation, (3) inside activities of daily living (ADL) (making meals, taking medicines, cleaning, painting,

**Table 3:** Individual direct ophthalmic medical costs expended for cataract surgery and societal, direct non-ophthalmic medical, direct non-medical, and indirect medical costs accrued by improving vision from 20/83 to 20/27 with cataract surgery (costs in 2018 U.S. real dollars unless otherwise indicated)

| Cost saved | 2018 cost saving (in negative 2018 U.S. real dollars*) | 14-year 2018 cost saving (in negative 2018 U.S. real dollars*) | 13-year 2012 cost saving (in negative 2012 U.S. real dollars) |
|---|---|---|---|
| Direct ophthalmic medical costs[6,8] | | | |
| Cataract surgery | $2,526 | $2,526 | $2,653 |
| Low vision services | –$2,238 | –$2,238 | NA |
| Direct non-ophthalmic medical costs[6,10] | | | |
| Depression** | –$653 | –$7,595 | –6,066 |
| Trauma** | –$441 | –$5,128 | –$4,096 |
| Skilled nursing facility** | –$990 | –$11,514 | –$9,196 |
| Other Medicare costs yet unidentified** | –$3,006 | –$34,973 | –$27,933 |
| Nursing home** | –$740 | –$8,607 | –$6,874 |
| Total direct non-ophthalmic medical** | –$5,830 | $67,817 | –$54,165 |
| Direct non-medical costs=caregiver[6,9] | | | |
| Inside ADL* | –$10,243 | –$119,176 | NA |
| Outside ADL* | –$1,693 | –$19,701 | NA |
| Transportation* | –$6,100 | –$70,972 | NA |
| Residence* | –$5,824 | –$67,759 | NA |
| Total direct non-medical* | –$23,860 | –$277,609 | –$45,152 |
| Indirect medical costs[6,9,12-14,*] | | | |
| Salary loss* | –$3,286 | –$24,879 | –$24,533 |
| Total societal costs (ophthalmic direct medical [excluding cataract surgery cost], non-ophthalmic direct medical, direct non-medical, and indirect medical costs) | –$35,214 | –$372,544 | –$123,850 |
| Net societal costs (with cataract surgery) | –$32,689 | –$370,018 | –$121,197 |
| Revenue (ROI) | –$35,125 | –$372,544) | –$123,850 |
| Societal cost return-on-investment (ROI) for the ophthalmic direct medical costs of cataract surgery | | | |
| | Annual compound rate for direct ophthalmic medical costs (%) | 14-year ROI (%) | |
| Unilateral surgery (14-year model) (2018 Oph. Dir. Med Cost = $2,526) (Cost savings = -$372,544) | 42.9 | 14,748 | |
| Bilateral Surgery (14-year model) (2018 Oph. Dir. Med. Cost = $5,052) Cost savings = -$372,544) | 36.0 | 7,374 | |
| Unilateral Surgery (13-year model) (2012 Oph. Dir. Med. Cost = $2,653) (Cost savings = -$123,261) | 34.4 | 4546 | |

(Negative costs indicate costs saved due to the vision improvement conferred by cataract surgery. * = 2012 and 2018 real costs adjusted from 2003 nominal costs using the CPI.[17]) (Negative costs indicate costs saved due to vision improvement from cataract surgery. **2003 costs adjusted to 2012 and 2018 real U.S. dollars using the Medical Care component of the CPI[17] NA: Not available, Oph. Dir. Med. Cost=ophthalmic direct medical cost), CPI: Consumer price index

**Table 4:** All cataract surgery costs and Medicare Fee Schedule surgeon's fees (adjusted using the Medical Care CPI[17] to 2018 real U.S. dollars)

| Year | All cataract surgery costs | Percentage of 1985 cost (%) | Reduction from 1985 cost (%) | Surgeon fee | Percentage of 1985 cost (%) | Reduction from 1985 cost (%) |
|---|---|---|---|---|---|---|
| 1985[5] | $20,910 | 100.0 | 0.0 | $8,745 | 100.0 | 0.0 |
| 2000[4] | $4,131 | 19.8 | 80.2 | $1,224 | 14.0 | 86.0 |
| 2012[5] | $3,128 | 15.0 | 85.0 | $897 | 10.3 | 89.7 |
| 2018[6] | $2,526 | 12.1 | 87.9 | $656 | 7.5 | 92.5 |

**Table 5:** Year 2000 and 2012 Medicare Physician, Fee Schedule Reimbursements (in 2018 U.S. Medical Care CPI-Adjusted Dollars)[1,8,17]

| Intervention (CPT code)[8] | 2018 Cost (in 2018 dollars) | 2000 Cost (in 2018 dollars)[17] | % Decrease: 2000 to 2018 | 2012 Cost (in 2018 dollars)[5,17] | % Decrease: 2012 to 2018[17] |
|---|---|---|---|---|---|
| Appendectomy, open (44950) | $669 | $872 | −23.3 | $752 | −11.1 |
| Cholecystectomy, open (47600) | $1112 | $1176 | −5.5 | $1266 | −12.2 |
| Cholecystectomy, laparoscopic (47562) | $685 | $1134 | −39.6 | $877 | −21.9 |
| CABG, 1 vessel (33510) | $2012 | $3192 | −37.0 | $2376 | −15.3 |
| Total hip arthroplasty (27130) | $1409 | $2515 | −44.0 | $1705 | −17.3 |
| Total knee arthroplasty (27447) | $1408 | $2660 | −47.1 | $1820 | −22.6 |
| Inpatient hospital consult (99223) | $206 | $252 | −18.2 | $230 | −10.4 |
| Office/outpatient visit (99213) | $74 | $77 | −3.8 | $83 | −10.3 |
| Office/outpatient visit (99214) | $109 | $119 | −8.7 | $123 | −11.1 |
| Cataract surgery, 1st eye (66984) | $656 | $1220 | −46.2 | $897 | −26.9 |

CPI: Consumer price index, CPT: Current procedural terminology, CABG: Coronary artery bypass graft, venous, ROI: Return-on-investment

dressing, personal hygiene, etc.), and (4) outside ADL (garden work, lawn mowing, painting, house repairs, etc.) [Table 3].[7] Not well defined in 2012, these costs came from a more recent study of 200 consecutive older patients with vision loss.[9] Approximately 27% of caregiver costs were for paid caregivers and 73% for unpaid caregivers, typically family members, for whom wages were accrued as if they were paid at the $27.07 average national wage/hour.[9,11,12] All direct non-medical costs obtained from patients with vision loss were accrued at the July 2018, $27.07 average national hourly wage,[12] with the exception of residence costs, unless patients related an actual dollar amount.[9] The direct non-medical cost loss prevented by improved vision after first-eye cataract surgery totaled −$277,609.[6]

### Indirect Medical Costs

Included among the indirect medical costs accrued were the salary loss costs precluded by improved vision [Table 3]. These were calculated by assessing the percentage of patients aged 73–87 who worked. For ages 70–74 years, 19.2% of non-disabled people are employed, while for ages 75–79 years, 12.1% of non-disabled people are employed, and for ages 80–87, 8.4% of non-disabled people are employed.[13] It was assumed that the average person with 20/83 vision due to cataract fell into the category of difficulty seeing, not severe, for which the mean salary was 60.3% that of a non-disabled person, and for which the incidence of employment was 60.3% that of a non-disabled person.[13,14] Thus, the mean person with vision loss received total wages that were (60.3% × 60.3% =) 36.4% those of an age-matched, non-disabled person. The resultant mean 14-year salary loss gained by cataract surgery was −$24,879 per person.[12-14]

### Cost-utility Analysis Results from Companion Paper

The 2018, direct ophthalmic medical cost perspective model demonstrated in our companion paper[6] that first-eye cataract surgery yielded a 2.523 QALY gain, a 33.3% patient value gain, or 25.5% QOL gain versus no therapy. It also prevented a year of life loss and was associated with a very cost-effective CUR of $1001/QALY. Second-eye surgery yielded an 0.814 QALY gain, an 8.1% patient value gain, and very cost-effective CUR of $3101/QALY.

Institutional Review Board approval was not obtained for our cost-benefit analysis since it involved no individual patient data or identification, but rather peer-reviewed information already published in the literature. Acquisition of the patient vision utilities utilized was previously obtained with the

**Table 6:** Macroeconomic, 14-year cost data (2018 U.S. Dollar Real Dollars) for first-eye cataract operations performed on 1,907,318 conventional Medicare beneficiaries in 2018 (assuming 2017 conventional Medicare cataract surgery numbers)

| Intervention | Per person (*n*=1) (unless otherwise indicated) | Per conventional Medicare population *n*=1,907,318 patients *n*=3,337,807 cataract operations* |
|---|---|---|
| Ophthalmic direct medical costs (in $) | | Macroeconomic costs (in billions $) |
| Cataract surgery cost per operated eye | $2526 | $8.43 billion |
| Low vision services | –$2238 | –$4.27 billion |
| Total: Ophthalmic direct medical costs | $288 | $4.15 billion |
| Non-ophthalmic direct medical costs | | |
| Depression | –$7595 | –$14.49 billion |
| Trauma | –$5128 | –$9.78 billion |
| Skilled nursing facility | –$11,514 | –$21.96 billion |
| Other Medicare costs as yet unidentified | –$34,973 | –$66.71 billion |
| Nursing home costs | –$8607 | –$16.42 billion |
| Total: Non-ophthalmic direct medical costs | –$67,817 | –$112.93 billion |
| Direct non-medical costs | | |
| Inside ADL | –$119,176 | –$227.31 billion |
| Outside ADL | –$19,701 | –$37.58 billion |
| Transportation | –$70,972 | –$135.37 billion |
| Residence | –$67,759 | –$129.24 billion |
| Total: Direct non-medical costs | –$277,609 | –$529.49 billion |
| Indirect medical costs | | |
| Salary loss | –$24,879 | –$47.45 billion |
| Total: Indirect non-medical costs | –$24,879 | –$47.45 billion |
| Total net societal cost per person for first-eye cataract surgery in column 1 and per 1,907,318 conventional Medicare beneficiaries undergoing first-eye cataract surgery in column 2 | –$370,018 | –$702.18 billion |
| Societal costs offsetting cataract surgery costs from first-eye surgery = revenue | –$372,544 | –$710.56 billion |
| Net dollars returned to society for each $1 spent on cataract surgery | $147.48 returned to society per $1 spent for first eye surgery | $147.48 returned to society per $1 spent for first eye surgery |

*The macroeconomic costs accruing against the direct costs of cataract surgery are per the conventional Medicare beneficiary cataract surgery population (*n*=1,907,318) in the right column. Middle column costs are per person. All except the direct costs of cataract surgery accrue against the costs of cataract surgery. **The macroeconomic cost for cataract surgery includes 3,337,807 eyes in the right column. Low vision service costs are per patient assumed to occur one time per patient over 14 years

approval of the Wills Eye Hospital Institutional Review Board using the Declaration of Helsinki guidelines.

## RESULTS

### Ophthalmic Direct Medical Costs Expended for Cataract Surgery

The 2018 direct ophthalmic medical costs of cataract surgery totaled $2,516 while the surgeon fee was $656 [Table 4].[8] Compared to the Medical Care Consumer Price Index (CPI)-adjusted costs[17] of cataract surgery in prior years, the overall cost of cataract surgery in 2018 was 12.1% of the cost in 1985 [Table 4]. The 2018 cataract surgeon fee of $656, adjusted with the Medical Care CPI 17, was 7.5% of that in 1985 [Table 4]. Conversely, the cataract surgeon Medical Care CPI-adjusted fee has decreased 92.5% since 1985. The overall cataract surgery costs/surgeon fee costs in 2018 referent to 2012 were reduced by 19.2%/26.9%, referent to 2000 were decreased by 38.9%/46.4%, and referent to 1985 were reduced by 87.9%/92.5%.

**Table 7:** 2018 Cataract Surgery Cohort U.S. Real Dollar Ophthalmic Direct Medical Costs Associated with 14-year Societal Return to the U.S. GDP

| Entity | Cost/person | People (*n*) | Total (000's) |
|---|---|---|---|
| Unilateral cataract surgery | $2,526 | 476,830 | $1,204,272 |
| Bilateral cataract surgery | $5,052 | 1,430,489 | $7,226,830 |
| Employment - wage gains | $24,879 | 1,907,319 | $47,452,959 |
| Caregiver gain (73% of all caregiver costs) | $230,415 | 1,907,319 | $386,526,912 |
| Caregiver loss (27% of all caregiver costs) | –$74,974 | 1,907,319 | –$142,962,008 |
| Non-ophthalmic direct medical costs, including nursing home | –$67,817 | 1,907,319 | –$129,348,653 |
| Total costs adding to GDP | $259,715 | 1,907,319 | $442,411,175 |
| Total cost subtracting from GDP | –$142,771 | 1,907,319 | –$272,310,661 |
| Total costs accruing to the GDP | $116,914 | 1,907,319 | $170,100,514 |
| Total costs accruing to the GDP per person undergoing cataract surgery | - | 1 | $89,183 |

GDP: Gross domestic product

A comparison of the medical-CPI-inflation-adjusted reductions for the 2018 cataract surgeon's fee from the years 2012 and 2000 compared to physician fee reductions in the Medicare Part B Fee Schedule associated with nine common, non-ophthalmic interventions across medicine is shown in Table 5. The 2012–2018 non-ophthalmic physician fee reductions ranged from 10.3% for an outpatient office visit (CPT code 99213) to 22.6% for total knee arthroplasty (CPT code 27447). The surgeon fee reduction for cataract surgery (CPT code 66984) over the same time period was the highest among the group at 26.9%. The year 2000–2018 physician fee reductions ranged from 3.8% for an outpatient office visit (CPT code 99213) to 47.1% for total knee arthroplasty (CPT code 27447); the only intervention for which the physician fee reduction exceeded the cataract surgeon fee reduction of 46.2%.

The seven surgeon fee reductions from 2000 to 2018 averaged −34.7%, while the three medical interventions averaged a −10.2% decrease.

### Societal Costs Associated with Cataract Surgery

The societal (ophthalmic direct medical, non-ophthalmic direct medical, direct non-medical, and indirect medical) costs accruing against the costs of the year 2018 and 2012 cataract surgery due to the improved vision after cataract removal are shown in Table 3. The 14-year costs accruing against 2018 cataract surgery costs were −$2,238 in the ophthalmic direct medical cost category for low vision aids,[9] a cost not addressed in our 2012 analysis.[5] The 14-year, non-ophthalmic direct medical costs, including nursing home costs, totaled −$67,817 in 2018 versus −$45,152 in 2012. Caregiver costs of inside and outside ADL, transportation, and residence in 2018 totaled −$277,609, while in 2012, they totaled only −$45,152 since less detailed costs[11] were available. The 14-year productivity (salary loss) cost in 2018 was −$24,879 versus −$24,533 in 2012. Thus, the most dramatic societal cost change from 2012 to 2018 was the total caregiver or direct non-medical cost. The total cost accruing against cataract surgery cost in 2018 was −$372,544 versus −$123,850 in 2012 (−$139,988 in U.S. 2018 real dollars). The net total cost associated with cataract surgery, including the surgical cost of $2526 in 2018, was −$370,018 versus −$121,197 in 2012, the latter amount adjusted with a Medical Care CPI to −$137,160 in 2018 real dollars. This resulted in an overall gain to society of $232,858 or ($232,858/$137,160 =) 170% in 2018 real dollars from 2012 to 2018.

The 2018, 14-year ROI for unilateral cataract surgery was ($372,543/$2,526 =) 14,748%, an annual ROI of 42.9%, versus a 13-year ROI of 4546% and annual ROI of 34.4% in 2012 [Table 3].[5] The 2018, 14-year ROI for bilateral cataract surgery was ($362,440/$5,052 =) 7374%, an annual ROI of 36.0%.

### Macroeconomic Costs

The macroeconomic costs associated with cataract surgery in the conventional Medicare population in 2018 are listed in Table 6.

### 2018 Cataract Patient and Cataract Operations

The number of cataract surgery patients (1,907,318) and cataract operations (3,337,807) in 2017 are assumed to be unchanged in our 2018 analysis. The number of overall Medicare enrollees has increased every year since 1985, with an increase of at least 1.4 million members each year from 2013 through 2017.[20] In 2017, total Medicare enrollment was 58.5 million, with 38.7 (66.2%) million enrolled in conventional Medicare and 19.8 million (33.8%) enrolled in Medicare Advantage (Medicare C), the latter a managed care program run by non-Medicare insurers that contract with Medicare to take care of patients for a set fee.[20] In 2018, 35% of Medicare beneficiaries were in Medicare Advantage and

**Table 8:** First-eye cataract surgery. Individual Patient Ophthalmic Direct Medical Costs Expended and Societal Costs Returned Per Payer (2018 U.S. Dollar Real Costs)

| Payer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Costs** | **Total (%)** | **Medicare** | **Medicaid** | **Employer–Sponsored** | **Medigap** | **Military Insurance** | **Uninsured** | **Patient** |
| Cataract surgery, first eye* | $2,526 (100%) | $1,866 (73.9%) | $147 (5.8%) | $130 (5.2%) | $138 (5.5%) | $189 (7.5%) | $30 (1.2%) | $25 (1.0%) |
| Non-cataract ophthalmic (low vision) costs[9] | –$2,238 (–100%) | –$166 (–7.4%) | –$159 (–7.1%) | 0 | 0 | –$16 (–0.7%) | –$27 (–1.2%) | –$1,871 (–83.6%) |
| Direct non-ophthalmic medical costs[10] | –$59,210 (–100%) | –$43,744 (–73.9%) | –$3,434 (–5.8%) | –$3,055 (–5.2%) | –$3,233 (–5.5%) | –$4,441 (–7.5%) | –$711 (–1.2%) | –$592 (–1.0%) |
| Nursing home[10] | –$8,607 (–100%) | –$1,119 (–13%) | –$3,873 (–45%) | 0 | 0 | 0 | –$103 (–1.2%) | –$3,512 (–40.8%) |
| Employment[7,12-15] | –$24,879 (–100%) | 0 | 0 | 0 | 0 | 0 | –$299 (–1.2%) | –$24,580 (–98.8%) |
| Direct non-medical (caregiver) [10] | –$277,609 (–100%) | 0 | 0 | 0 | 0 | 0 | –$3,331 (–1.2%) | –$274,278 (98.8%) |
| Overall total cost | –$370,017 (–100%) | –$43,163 (–11.7%) | –$7,320 (–2.0%) | $2,925 (–0.8%) | $3,095 (–0.8%) | $4,257 (–1.1%) | –$4,440 (–1.2%) | –$304,909 (–82.4%) |
| Revenue=monetary ROI for cataract surgery costs | –$372,543 | –$45,029 | –$7,466 | –$3,055 | –$3,233 | –$4,456 | –$1,471 | –$304,833 |
| Annual compound rate for the revenue gained from cataract surgery costs | 42.9% | 25.9% | 32.6% | 25.6% | 25.6% | 25.6% | 43.0% | 95.7% |
| 14-year ROI for the revenue gained from cataract surgery costs expended | 14,748% | 2,413% | 5,096% | 2,344% | 2,344% | 2,352% | 14,748% | 1,206,781% |

The direct ophthalmic medical costs of cataract surgery paid by the different entities are considered positive costs. The costs accruing against the direct medical costs of cataract surgery are considered negative costs. Non-ophthalmic direct medical costs[10] = costs for depression, trauma, subacute nursing facilities, and other unidentified Medicare costs. ROI: Return-on-investment

65% in conventional Medicare.[20] While the overall Medicare enrollee gain in 2017 Medicare was 1.42 million, only 65,929 (4.4%) of the new members enrolled in conventional Medicare, increasing the conventional Medicare population by only (65,929/38,676,313 =) 0.17% and supporting our premise to base our 2018 conventional Medicare population analysis on 2017 cataract patient and surgery numbers.[1] Our data do not include Medicare Advantage patients, who comprise 35% of Medicare beneficiaries.[20] If the Medicare Advantage cataract surgery incidence parallels that in the conventional Medicare population, the number of cataract operations in 2018 in the U.S. would be in the range of 5.12 million performed on 2.92 million patients.

### Age

Approximately 17% of the Medicare-enrolled population is under age 65 years and enrolled in Medicare due to disability eligibility.[20] Since the mean age at cataract surgery in our analysis was 73 years (median age of 77.1 years in the Royal College of Ophthalmologists' National Ophthalmology Database Study),[6] and only 17% of the Medicare-enrolled population is under the age of 65,[20, 21] we are assuming that the great majority of the 1.9 million patients with conventional Medicare health insurance coverage undergoing 3.338 million cataract surgery operations are seniors (age >64 years).[1,22] Age is relevant for the calculated dollars expended by and accrued to different insurance (public and private) carriers and patients.

### Total Costs Expended for 2018 Conventional Medicare Enrollee, Cataract Surgery

Table 6 shows the per person and the 2018 conventional Medicare, cataract surgery population costs. The 2018 ophthalmic direct medical cost for cataract surgery, which was the only cost expended, was an exception to the per person rule. The overall cost was calculated per operation and found to be $8,431 billion ($2,526 per operation × 3,337,807 cataract operations).

### Total Costs (Revenue) Accrued Against 2018, Conventional Medicare Population, Direct Medical Costs Of Cataract Surgery [Table 6]

Unlike the direct medical costs of cataract surgery which are per eye, the revenue costs accruing against the direct medical costs of cataract surgery are per person, since these are gained when the first eye undergoes cataract surgery, but not when the second eye undergoes cataract surgery. The 14-year, ophthalmic, direct medical costs for low vision services and aids obviated by better vision after cataract surgery totaled −$4.27 billion.

The 14-year, non-ophthalmic direct medical costs averted for all 2018 conventional Medical enrollees totaled −$112.9 billion. Depression costs precluded were −$14.5 billion, trauma costs saved were −$9.8 billion, skilled nursing facility costs avoided were −$22.0 billion, Medicare costs as yet unidentified precluded −$66.7 billion, and nursing home costs obviated were −$16.4 billion.

Fourteen-year direct non-medical (caregiver) costs prevented totaled −$529.5 billion, including −$227.3 billion for inside ADL, −$37.6 billion for outside ADL, −$136.4 billion for transportation, and −$129.2 for residence and residence change. Indirect medical costs, also known as productivity or salary loss costs, totaled −$47.5 billion over 14 years.

The total societal revenue offsetting the 2018 $8.43 billion ophthalmic direct medical cost of cataract surgery was −$710.56 billion, yielding a net $702.13 billion gain to society as a result of 2018 cataract surgery. This total revenue gain converts to a net 14-year societal return of a mean $147.48 for every dollar spent on the ophthalmic direct medical costs of first-eye cataract surgery. No additional societal costs were returned by second-eye cataract surgery since we were unable to find peer-reviewed data suggesting that improving vision in a second eye returns additional societal costs when the first eye has good vision.

### Contribution to the Gross Domestic Product (GDP)

By definition, the GDP is the monetary value of all finished goods and services produced within a country within a specified period of time, typically 1 year.[23] The GDP is often used to quantify the overall economic activity, standard of living, or wealth of a nation. It is adjusted from year to year to allow seamless comparisons over periods of time and is thus a "real," rather than "nominal" GDP. The GDP is composed of (1) personal consumption and expenditure (69%), government consumption expenditure and gross investment (17%), (3) gross private domestic investment (16%), and (4) net exports (−3%) (calculated by subtracting total imports from total exports).[23]

The effect of 2018 cataract costs on the U.S. GDP is shown in Table 7. The total GDP contribution of the 2018 cohort of cataract surgery over 14 years is $170.1 billion, a mean $89,183 for each person undergoing cataract surgery. Costs accruing to the GDP included $442 billion in cataract surgery costs, wage gains, and costs for the 73% of caregivers who are unpaid and freed up to pursue gainful employment, while those subtracted from the GDP included the $272 billion for the 27% of paid caregivers not needed after surgery, and the direct non-medical (depression, trauma, facility admissions, nursing home, etc.) costs precluded by improved vision.

### ROI to Payers

The financial ROI to different health insurance payers and others for a patient undergoing first-eye cataract surgery is shown in Table 8.[24-27] The model is based on the senior population (>64 years) in conventional Medicare.[3] The results in Table 8 for the individual patient undergoing

**Table 9:** Combined-eye (weighted) cataract surgery. Macroeconomic ophthalmic direct medical costs expended and societal costs returned per payer (2018 U.S. Dollar Real Costs, in Billions)

| Payer | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Costs** | **Total** | **Medicare** | **Medicaid** | **Employer-sponsored** | **Medigap** | **Military insurance** | **Uninsured** | **Patient** |
| Cataract surgery, first eye and second eye* | $8.43 (100%) | $6.23 (73.9%) | $0.49 (5.8%) | $0.49 (5.8%) | $0.46 (5.2%) | $0.63 (7.5%) | $0.10 (1.2%) | $0.08 (1.0%) |
| Non-cataract ophthalmic (low vision) costs[9] | −$4.27 (−100%) | −$0.32 (−7.4%) | −$0.30 (−7.1%) | 0 | 0 | −$0.030 (−0.7%) | −$0.05 (−1.2%) | −$3.57 (−83.6%) |
| Non-ophthalmic direct medical costs[10] | −$112.93 (−100%) | $83.43 (−73.9%) | −$6.55 (−5.8%) | −$5.83 (−5.2%) | −$6.17 (−5.5%) | −$8.47 (−7.5%) | −$1.36 (−1.2%) | −$1.13 (−1.0%) |
| Nursing home[10] | −$16.42 (−100%) | −$2.13 (−13%) | −$7.39 (−45%) | 0 | 0 | 0 | −$0.20 (−1.2%) | −$6.70 (−40.8%) |
| Employment[9,12-14] | −$47.45 (−100%) | 0 | 0 | 0 | 0 | 0 | −$0.57 (−1.2%) | −$46.84 (−98.8%) |
| Direct non-medical (caregiver)[9] | −$529.49 (−100%) | 0 | 0 | 0 | 0 | 0 | −$6.35 (−1.2%) | −$523.14 (98.8%) |
| Overall total cost=revenue – cataract surgery expense | −$702.13 (−100%) | −$79.66 (−11,3%) | −$13.75 (−1.9%) | −$5.39 (−0.7%) | −$5.71 (−0.8%) | −$7.87 (−1.1%) | −$8.43 (−1.2%) | $581.93 (−82.9%) |
| Revenue=monetary ROI gained from cataract surgery costs | −$710,558 | −$85,884 | −$14,240 | −$5,827 | −$6,166 | −$8,502 | −$8,527 | −$582,015 |
| Annual compound rate for revenue gained for cataract surgery costs | 37.3% | 20.6% | 26.7% | 20.4% | 20.4% | 20.4% | 37.1% | 88.0% |
| 14-year ROI for the revenue gained by cataract surgery costs expended | 8,428% | 1,379% | 2,912% | 1,339% | 1,339% | 1,345% | 8,428% | 890,327% |

The direct ophthalmic medical costs of cataract surgery paid by the different entities are considered positive costs. The costs accruing against the direct medical costs of cataract surgery are considered negative costs. *Note that the insurance premium costs expended by patients are not included. Non-ophthalmic direct medical costs[10] = costs for depression, trauma, subacute nursing facilities, and other unidentified Medicare costs. ROI: Return-on-investment

**Table 10:** Sensitivity analysis. First eye (better-seeing eye) financial return-on investment for cataract surgery at different visions (2018 U.S. Real Dollars)

| Visual acuity | 14-year Dollar ROI=Revenue | 14-year ROI=Revenue/ cataract surgery cost (%) | Annual compounded rate of return (%) |
|---|---|---|---|
| 20/83 | $372,543 | 14,748 | 42.9 |
| 20/60 | $372,543 | 14,748 | 42.9 |
| 20/50 | $223,206 | 8936 | 37.7 |
| 20/40 | $125,375 | 5063 | 32.1 |
| 20/30 | $122,849 | 5963 | 32.1 |
| 20/25 | $0 | 0 | 0 |

first-eye cataract surgery demonstrate greater 14-year ROIs than in Table 9, which reflects the weighted macroeconomic results from both 2018 first-eye and second-eye cataract surgeries. Medicare, the major payer, pays 73.9% of the individual and macroeconomic, ophthalmic direct medical costs of cataract surgery, for a total of $6.23 billion for the latter [Table 9]. Each payer has a positive ROI for the ophthalmic direct medical costs expended on cataract surgery, indicating a net gain in revenue above the costs of surgery. The 14-year monetary ROI from not having to pay non-ophthalmic direct medical costs (including nursing home costs) is $85.56 billion for Medicare. The Medicare costs accruing against those of cataract surgery result in a 14-year ROI for the cataract surgery costs of 1379%, an annual compounded rate of 20.6%. Medicaid costs, which occur predominantly in conjunction with Medicare costs in the senior population,[27] pay 5.8% of all cataract surgery costs or $490 million. The Medicaid, 14-year dollar revenue of $14.24 billion, a 2812% 14-year ROI, or 26.7% annual compounded rate, comes in large part (52%) from the $7.39 billion in nursing home costs precluded and 46% from the $6.55 billion in non-ophthalmic direct medical costs precluded.

The greatest ROI is to patients. Excluding health insurance premiums, insured cataract surgery patients (98.8% of the patient cohort) pay $80 million in out-of-pocket costs, 1.0% of cataract surgery costs. The monetary ROI (revenue), however, is $582.02 billion, 82.9% of the net societal revenue of $710.54. This results in a 14-year ROI of 890,327%, an annual compounded interest rate of 88.0%, from decreased low vision costs, decreased non-ophthalmic direct medical costs, and salary gains for cataract surgery patients and unpaid family caregivers.

### Sensitivity Analysis

The net societal costs change as the pre-operative vision in the better-seeing eye undergoing cataract surgery changes [Table 10]. There is no change in the societal revenue of $372,543 accrued with either 20/83 or 20/60 vision. At 20/50 pre-operative vision, the non-ophthalmic direct medical costs are unchanged, but the direct non-medical costs decrease by $149,247, resulting in a societal monetary ROI of $223,206 for the $2,526 cataract surgery costs expended. At 20/40 pre-operative vision, the low vision costs and non-ophthalmic direct medical costs drop out. The 14-year societal monetary ROI of $122,849 is the same for 20/40 and 20/30 vision because some direct non-medical (caregiver) costs accruing against the cataract surgery costs remain. With 20/25 pre-operative vision, no societal costs are accrued against the ophthalmic direct medical costs of cataract surgery.

## DISCUSSION

Our analysis indicates that 2018 cataract surgery in the first eye delivers a $372,543 monetary ROI for the ophthalmic direct medical costs of surgery expended. This is far greater than the $123,850 ROI in our 2012 analysis.[5] The primary reason for the greater ROI in 2018 is that the increased direct non-medical (caregiver) costs have been much better defined in the interim between the papers.[9] Caregiver (ADL, transportation, and residence) costs account for ($277,609/$372,544 =) 74.5% of the revenue returned to society after first-eye cataract surgery. Our rationale in including the costs of the 73% of caregivers who were unpaid, typically family, was that they would be freed up to obtain gainful employment, thus bringing in monetary return to the family and patient. Since this is an era of U.S. "full employment," with the unemployment rate <4%,[28] a number that can account for those in-between jobs,[29] we presume the great majority of people who want to work can obtain paid employment.

While second-eye cataract surgery has no societal monetary return when the first eye already has good vision after cataract surgery, it returns considerable patient value (improvement in QOL) and is highly cost-effective at $3,101/QALY referent to the majority of interventions across medicine.[7] Our cost-benefit analysis in the manuscript herein should in no way be interpreted that second-eye cataract surgery should not be performed. The take-home message is that first-eye cataract surgery yields an extraordinary patient value ROI and financial ROI, while second-eye cataract surgery yields substantial patient value gain, including better depth

perception and less anxiety associated with having good vision in one eye only.[7]

Patients are the main financial beneficiaries of the ROI from first-eye cataract surgery, receiving 82.4% of the funds, with a 14-year ROI of 1,206,781% and annual compounded interest rate of 95.7%. This equates to a 14-year monetary ROI of $12,068 for every out-of-pocket dollar spent on cataract surgery (excluding insurance premiums and possible varying copays, which were not addressed in our analysis) and far exceeds the 20.9% annual Berkshire Hathaway financial ROI under the leadership of one of the world's most acclaimed investors, Warren Buffett.[30]

Even though the Medicare ROI is less spectacular than the patient ROI, Medicare has a 14-year ROI of 2,413% for first-eye surgery, an annual ROI of 25.9%, with $45,029 returned for the $1,866 spent [Table 8]. This equates to $24.13 returned to Medicare for every dollar spent on first-eye cataract surgery. The major reason for the excellent ROI is that better vision obviates the non-ophthalmic direct medical costs associated with depression, trauma, facility admissions, and others. Adding the $1,866 Medicare cost of each second-eye cataract surgery, with no societal ROI, to the cost of first-eye surgery, reveals a combined-revenue return, or ROI, for weighted first-eye and second-eye surgeries of $13.79 for each dollar Medicare spends.

Medicaid has a 14-year revenue return, or ROI, of 5096%, with a $50.96 ROI for each dollar expended on first-eye surgery. Weighting first-eye and second-eye cataract surgeries results in a $29.50 financial return to Medicaid for each dollar spent. Non-Medicare and non-Medicaid insurers also fare well, with a first-eye surgery, annual compounded interest rate on cataract surgery costs of 25.6%, a 2,344%–2,352% 14-year ROI, and a mean net financial return of $23.44–$23.52 per $1 spent on cataract surgery.

The contribution to the GDP strongly suggests that cataract surgery makes the nation wealthier. Intuitively, it is reasonable to believe that a healthier, less dependent population can contribute to the generation of greater resources from gainful employment and enable people such as unpaid caregivers to be freed-up to pursue gainful employment. William Nordhaus, the Nobel Prize winning economist, has suggested that 50% of the wealth created in the United States in the 20th century came about as a result of advances in health and healthcare.[31] He showed that economic productivity associated with healthcare spending exceeds that of other economic expenditures. Our analysis numbers support this supposition. While the U.S. direct medical care expenditure is believed extravagant by many,[7] the societal financial ROI associated with interventions can dramatically exceed the direct medical costs, as seen herein. Thus, critical factors in healthcare economics in addition to overall healthcare spending include (1) patient (human) value gain, (2) cost-effectiveness, and (3) the financial value (ROI) associated with direct medical costs expended.

The direct medical cost of cataract surgery deserves mention. The discounted, 2018 cost of the procedure is 12.1% of what it was in 1985. This can be explained in part by more efficient surgery than in 1985 due to improved surgeon experience, better instrumentation, and outpatient surgery. The decrease in surgeon fee to 7.5% in 2018 compared to what it was in 1985 is more striking yet. Although common interventions across medicine have all undergone fee reductions since 2000 and 2012 [Table 5], the comparative data suggest that the cataract surgeon fee reduction has been among the most severe.

## CONCLUSIONS

In summary, cataract surgery creates considerable financial value or societal monetary ROI for the direct medical costs expended for the surgery, as well as patient value. The net financial ROI from cataract surgery to patients, Medicare, Medicaid, and commercial insurers is substantial and greater than demonstrated in 2012. Each of the insurers has a double-digit return on the costs expended that would be considered extraordinary in the financial markets. Cataract surgery creates considerable economic wealth for the country as it improves the QOL and length of life.

## REFERENCES


1. Part B Physician/Supplier National Data-CY 2017. Top 200 Level Current Terminology (HCPCS/CPT) Codes. Available from: https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/MedicareFeeforSvcPartsAB/Downloads/LEVEL2SERV17.pdf. [Last accessed on 2018 Aug 30].
2. Schein OD, Steinberg EP, Javitt JC, Cassard SD, Tielsch JM, Steinwachs DM, *et al.* Variation in cataract surgery practice and clinical outcomes. Ophthalmology 1994;101:1142-52.
3. Day AC, Donachie PH, Sparrow JM, Johnston RL, Royal College of Ophthalmologists' National Ophthalmology Database. The royal college of ophthalmologists' national ophthalmology database study of cataract surgery: Report 1, visual outcomes and complications. Eye (Lond) 2015;29:552-60.
4. Busbee BG, Brown MM, Brown GC, Sharma S. Incremental cost-effectiveness of initial cataract surgery. Ophthalmology 2002;109:606-12.
5. Brown GC, Brown MM, Menezes A, Busbee BG, Lieske HB, Lieske PA, *et al.* Cataract surgery cost utility revisited in 2012: A new economic paradigm. Ophthalmology 2013;120:2367-76.
6. Brown GC, Brown MM, Busbee BG. A cost-utility analysis of 2018 cataract surgery in the United States submitted for publication.
7. Brown MM, Brown GC, Sharma S. Evidence-Based to Value-Based Medicine. Chicago: AMA Press; 2005. p. 1-324.
8. CMS.gov. Medicare Physician Fee Schedule Search. Available from: https://www.cms.gov/apps/physician-fee-schedule/

search/search-criteria.aspx. [Last accessed on 2018 Sep 10].
9. Brown MM, Brown GC, Lieske HB, Tran I, Turpcu A, Colman S, *et al.* Societal costs associated with neovascular age-related macular degeneration in the United States. Retina 2016;36:285-98.
10. Javitt JC, Zhou Z, Willke RJ. Association between vision loss and higher medical care costs in medicare beneficiaries costs are greater for those with progressive vision loss. Ophthalmology 2007;114:238-45.
11. Schmier JK, Halpern MT, Covert D, Delgado J, Sharma S. Impact of visual impairment on use of caregiving by individuals with age-related macular degeneration. Retina 2006;26:1056-62.
12. Bureau of Labor Statistics. Economic News Release. Real earnings. Table A-1. Current and Real (Constant 1982-1984 dollars) Earnings for all Employees on Private Nonfarm Payrolls, Seasonally Adjusted; 2018. Available from: https://www.bls.gov/news.release/pdf/realer.pdf. [Last accessed on 2018 Oct 17].
13. Real Earnings; 2018. Available from: http://www.file:///C:/Users/gary0/Documents/Gary%204-9-18/Gary%208-13-17/PAPERS%20FOR%20PUBLIC/Cataract%20surgery%20CUA%202018/Journal%20of%20Cataract%20and%20Refractive%20Surgery/Cost-benefit%20paper/Employment/mean%20wage.pdf. [Last accessed on 2018 Sep 10].
14. U.S. Bureau of Labor Statistics. Employment Status of the Civilian Non Institutional Population by Age, Sex, and Race. Available from: https://www.bls.gov/cps/cpsaat03.htm. [Last accessed on 2018 Sep 10].
15. Employment, Monthly Earnings, and Monthly Family Income Among Individuals 21 to 64 Years Old by Specific Measures of Disability; 2010. Available from: https://www.census.gov/prod/2012pubs/p70-131.pdf. [Last accessed on 2018 Sep 10].
16. Christ SL, Zheng DD, Swenor BK, Lam BL, West SK, Tannenbaum SL, *et al.* Longitudinal relationships among visual acuity, daily functional status, and mortality: The salisbury eye evaluation study. JAMA Ophthalmol 2014;132:1400-6.
17. Bureau of Labor Statistics. All items in U.S. City Average, All Urban Consumers, not Seasonally Adjusted and Medical Care in U.S. City Average, All Urban Consumers, not Seasonally Adjusted. Available from: https://www.data.bls.gov/pdq/SurveyOutputServlet. [Last accessed on 2018 Aug 31].
18. CMS.gov. Addendum AA-Final ASC Covered Surgical Procedures for CY 2018 (Including Surgical Procedures for Which Payment is Packaged). Available from: https://www.federalregister.gov/documents/2007/11/27/07-5507/medicare-program-changes-to-the-hospital-outpatient-prospective-payment-system-and-cy-2008-payment. [Last accessed on 2018 Sep 01].
19. Centers for Medicare and Medicaid Services Anesthesiologists Center. Locality-Adjusted Anesthesia Conversion Factors as a result of the CY 2018 Final Rule. Available from: https://www.cms.gov/Center/Provider-Type/Anesthesiologists-Centerd.r.html?redirect=/center/anesth.asp. [Last accessed on 2018 Sep 05].
20. CMS.gov/Medicare Enrollment Dashboard. Available from: https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/CMSProgramStatistics/Dashboard.html. [Last accessed on 2018 Sep 16].
21. The Henry J. Kaiser Family Foundation. An overview of Medicare; 2017. Issue Brief. Available from: https://www.kff.org/medicare/issue-brief/an-overview-of-medicare/. [Last accessed on 2018 Sep 16].
22. Cubanski J, Neuman T, Damico A. Medicare's Role for People Under Age 65 with Disabilities. Available from: https://www.kff.org/medicare/issue-brief/medicares-role-for-people-under-age-65-with-disabilities. [Last accessed on 2018 Sep 16].
23. Investopedia. Gross Domestic Product-GDP. Available from: https://www.investopedia.com/terms/g/gdp.asp. [Last accessed on 2018 Sep 18].
24. Centers for Disease Control and Prevention. Health Insurance Coverage of Noninstitutionalized Medicare Beneficiaries Aged 65 and Over, by Type of Coverage and Selected Characteristics: United States, Selected Years 1992-2013, Table 106. Available from: https://www.cdc.gov/nchs/data/hus/2016/106.pdf. [Last accessed on 2018 Sep 02].
25. Cubanski J, Swoope C, Boccuti C, Jacobson G, Casillas G, Griffin S, *et al*. A Primer on Medicare: Key Facts about the Medicare Program and the People it Covers. Available from: https://www.kff.org/report-section/a-primer-on-medicare-what-types-of-supplemental-insurance-do-beneficiaries-have/. [Last accessed on 2018 Jan 09].
26. Jacobson G, Neuman T, Damico A. Medigap Enrollment Among New Medicare Beneficiaries: How Many 65-Year Olds Enroll In Plans With First-Dollar Coverage? Available from: https://www.kff.org/medicare/issue-brief/medigap-enrollment-among-new-medicare-beneficiaries/. [Last accessed on 2018 Jan 09].
27. Medicaid.gov. Seniors and Medicare and Medicaid enrollees. Available from: https://www.medicaid.gov/medicaid/eligibility/medicaid-enrollees/index.html. [Last accessed on 2018 Sep 21].
28. Bureau of Labor Statistics. Unemployment rate. Available from: https://www.data.bls.gov/timeseries/LNS14000000. [Last accessed on 2018 Sep 21].
29. Cox J. The jobs market may be past "full employment." Here's what that means. Available from: https://www.cnbc.com/2017/06/21/the-jobs-market-may-be-past-full-employment-heres-what-that-means.html. [Last accessed on 2018 Sep 21].
30. Maxfield J. An interesting chart about Berkshire Hathaway. Available from: https://www.fool.com/investing/2017/07/23/an-interesting-chart-about-berkshire-hathaway.aspx. [Last accessed on 2018 Sep 21].
31. Nordhaus WD. The Health of Nations: The Contribution of Improved Health to Living Standards. Working Paper 881. Cambridge, MA: National Bureau of Economic Research; 2002. p. 37-8.

**How to cite this article:** Brown GC, Brown MM, Busbee BG, Rapuano SB. A Cost-benefit Analysis of 2018 Cataract Surgery in the United States. Clin Res Ophthalmol 2019;2(1):1-13.