



An economic evaluation of phacoemulsification and extracapsular cataract extraction in cataract surgery

Farmakoekonomska evaluacija fakoemulzifikacije i ekstrakapsularne ekstrakcije u operaciji katarakte

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Abstract

Background/Aim. Cataract surgery is one of the most often performed surgical interventions. The predominant method in Western countries is phacoemulsification, while in developing countries, the extracapsular cataract extraction (ECCE) method remains popular. The aim of the study was to evaluate the cost-effectiveness of these two cataract surgery techniques from the provider's perspective if operation complications were the outcome of the interest. **Methods.** The data were obtained from the Department of Ophthalmology of the General Hospital Kruševac during a one-year period. A total of 1,179 surgeries by five surgeons were performed. The cost-effectiveness was evaluated using the decision tree. All probabilities were calculated based on the likelihood of the occurrence during the study period. Only direct costs were considered, and values were taken from the documentation at the hospital and the official price list of health services. One- and two-way sensitivity

analyses were performed. **Results.** The total cost per patient in the phacoemulsification group was 71,008.70 Serbian dinars (RSD), while the total cost in the ECCE group was 74,340.36 RSD. At the same time, phacoemulsification shows higher effectiveness than the ECCE method, with 87% and 57% of patients without complications, respectively. With these results, phacoemulsification was the dominant strategy compared to ECCE. The sensitivity analysis revealed that the results are sensitive to the number of performed operations per year. **Conclusion.** The phacoemulsification technique seems to be the preferred technique for cataract surgery. All the investment in phacoemulsification equipment and consumables is justified if the number of surgeries per year exceeds 350.

Key words:

cataract; cost-benefit analysis; ophthalmologic surgical procedures; phacoemulsification; economics, pharmaceutical; serbia.

Apstrakt

Uvod/Cilj. Operacija katarakte predstavlja jednu od najčešće primenjenih hirurških intervencija. U zapadnim zemljama, dominantna tehnika je fakoemulzifikacija, dok je u zemljama u razvoju najzastupljenija tehnika ekstrakapsularne ekstrakcije (ECCE). Cilj rada bio je da se proceni ekonomska isplativost te dve tehnike operacije katarakte iz perspektive pružaoca usluge, ukoliko se kao ishod posmatraju komplikacije. **Metode.** Podaci su dobijeni sa Očnog odeljenja Opšte bolnice Kruševac tokom jednogodišnjeg perioda. Ukupno je izvedeno 1 179 operacija od strane pet hirurga. Ekonomska isplativost je procenjena primenom „drveta odlučivanja“. Verovatnoće za događaje su izračunate na osnovu verovatnoće pojavljivanja tokom navedenog perioda. U analizi su razmatrani samo direktni troškovi, a vrednosti su preuzete iz prateće dokumentacije i zvaničnog cenovnika zdravstvenih usluga. Sprovedena je jednosmerna i dvosmerna analiza osetljivosti. **Rezultati.**

Ukupni troškovi u grupi koja je bila podvrgnuta fakoemulzifikaciji iznosili su 71 008.70 srpskih dinara (RSD), dok su u ECCE grupi oni iznosili 74 340.36 RSD. Istovremeno, fakoemulzifikacija je pokazala višu efikasnost u odnosu na ECCE, 87% i 57% bolesnika bez komplikacija, redom. Na osnovu dobijenih rezultata, fakoemulzifikacija je bila dominantna strategija u poređenju sa ECCE. Analiza osetljivosti pokazala je da su rezultati osetljivi na broj izvršenih intervencija na godišnjem nivou. **Zaključak.** Fakoemulzifikacija je ekonomski isplativija tehnika operacije katarakte u odnosu na ECCE. Sva ulaganje u opremu i potrošni materijal za fakoemulzifikaciju opravdani su ukoliko je broj izvedenih operacija na godišnjem nivou preko 350.

Ključne reči:

katarakta; troškovi-korist, analiza; hirurgija, oftalmološka, procedure; fakoemulzifikacija; farmakoekonomika; srbija.

Introduction

Visual impairment is a significant problem both for the affected individual and society in economic and social terms. According to the latest data from the World Health Organization, it is estimated that 39 million people worldwide are blind. The most significant cause of preventable blindness is cataract^{1,2}.

Prevalence rates of cataracts and blindness globally depend on the examination method, such as Lens Opacities Classification System (LOCS) III or Optical Quality Analysis System (OQAS), and diagnostic cut-off value used for best corrected visual acuity (VA) or presenting VA. However, the risk of cataracts increases with each decade of life, starting around age 40. Half of white Americans had cataracts by 75 years of age in 2010. It is forecasted that the number of people with cataracts will double from 24.4 million to about 50 million by the year 2050³. Results from Europe vary significantly, depending on the region, population, examination method, etc. The study from 2013 reflects this difference, from 6% in the Netherlands to almost 70% in Spain⁴. The most recent study from Sweden showed that the crude prevalence was 31.5%, with a higher percentage in the male population⁵. In Serbia, cataract was the second most frequent reason for hospitalizations in females in 2017, after breast cancer⁶.

Cataract surgery is one of the most often performed surgical interventions in developed countries. The predominant method of cataract surgery in Western countries is phacoemulsification. In randomized clinical trials, it produces better outcomes than extracapsular cataract extraction (ECCE)⁷. However, the ECCE method remains prevalent in developing countries due to its cost-effectiveness⁸.

The WHO has suggested that an annual rate of 350 surgeries per 100,000 inhabitants is a useful target against cataract blindness⁹.

This study aimed to compare the cost-effectiveness of two cataract surgery techniques, phacoemulsification and ECCE, by considering the occurrence of possible complications of the operation from the perspective of the health insurance (third-party payer).

Methods

The data for the analysis was obtained from the Department of Ophthalmology of the General Hospital Kruševac, Serbia. The hospital is the only public hospital that provides healthcare services for approximately 260,000 people in the Rasina district.

This study covered one year (from March 2019 to February 2020). During the study period, a total of 1,179 cataract surgeries (1,123 phacoemulsifications and 56 ECCE) were performed by five surgeons. All interventions were included in the analysis. Data on the efficacy of these two methods were calculated from patients' medical records. The retrospective analysis determined the number of patients with complications of cataract surgery that occurred in one or the other surgery method. This study was

approved by the hospital's Ethical Committee (No. 09/21 EO from April 19, 2021).

The cost-effectiveness of two types of cataract surgery was evaluated using the decision tree (Figure 1).

Probabilities

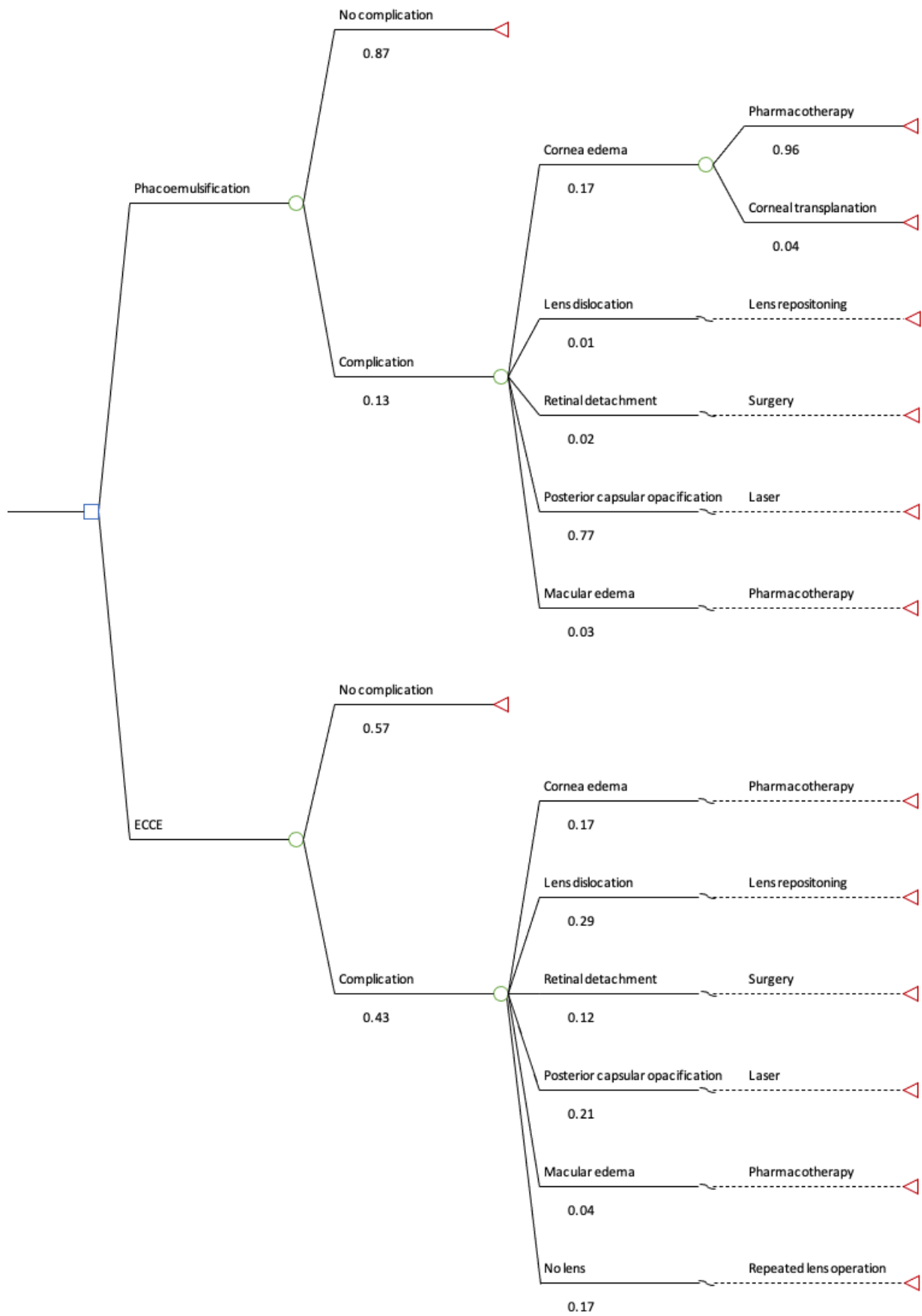
As the analysis outcome, complications during and after surgery were observed. In the phacoemulsification group, 146 out of 1,123 (13%) patients had complications, with 77% of posterior capsule opacification as the main complication. In the ECCE group, 43% of patients had complications, dominantly lens dislocation, occurring in 29% of cases. Probabilities for all outcomes and both techniques of surgery are presented in Figure 1.

Costs

Only direct costs were considered in the analysis. All costs are expressed in Serbian dinars (RSD), for which an exchange rate was as follows: 1 EUR = 117.5736 RSD for the year 2021, according to the National Bank of Serbia. Cost data were taken from the administrative documentation at the hospital and the official price list of health services of the Republic Institute for Health Insurance¹⁰. In the analysis, the following costs were included: the first consultation with an ophthalmologist, at which the indication for cataract surgery and scheduling of the operation itself happened; admission for surgery (Table 1); costs of the procedure itself (Table 2); follow-up controls after one and three weeks of the surgery; capital cost for the phacoemulsification machine. Besides the two previously mentioned controls, the ECCE group of patients also included the costs for the third and fourth control after surgery necessary for patients operated by this method.

Table 2 shows the costs of medicines, materials, and services provided during the cataract surgery itself. Most consumables are the same; the most prominent differences were for the lenses used – soft with the phacoemulsification method, hard with the ECCE method, and consumables for the phacoemulsification machine. During phacoemulsification, two types of knives are used, while the ECCE method uses one kind of knife, but also surgical suture is necessary afterward. Furthermore, patients in the ECCE group have an additional day of hospitalization compared to the phacoemulsification group.

The capital cost was included in the phacoemulsification group since it represented a fixed expense incurred on the purchase of equipment used for surgery. That consisted of the cost of the phacoemulsification machine itself, machine consumables, service, and instruments, considering that 1,000 operations are performed annually. The price of the phacoemulsification machine was 4.13 million RSD, and it has depreciated over five years. The cost per patient is calculated by dividing the machine's price by the estimated number of operations over five years (5,000). The cost of machine consumables per patient is calculated in the same manner.



**Fig. 1 – Decision tree used in the model.
ECCE – extracapsular cataract extraction.**

Table 1**Costs on admission to the hospital prior to surgery included in the analysis (independent of the technique performed).**

Variable	Number of units	Unit cost RSD	Total cost RSD
Specialist consultation	1	186.98	186.98
Topical anesthesia	2	58.30	116.60
Ophthalmoscopy	1	1,340.00	1,340.00
Ocular tonometry	1	1,600.00	1,600.00
Eye irrigation	1	93.49	93.49
Visual acuity	1	1,600.00	1,600.00
Consumables (compress, solutions, etc.)			7.68
Total			4,944.75

RSD – Serbian dinars.

Table 2**Costs of services, medicines, medical devices, and consumables provided during the cataract surgery**

Variable	ECCE		Phacoemulsification	
	number of units	RSD	number of units	RSD
Services				
peribulbar application of an anesthetic surgery	1	1,800.00	1	1,800.00
subconjunctival application of medicine	1	38,284.19	1	38,284.19
sedation	1	1,340.00	1	1,340.00
in-patient day at the general ward	1	2,810.00	1	2,810.00
in-patient day at the semi-intensive unit	1	1,545.40	1	1,545.40
	2	4,467.08	1	2,233.54
Medicines				
Lens		574.63		553.33
Knives	1	682.00	1	3,626.70
Other consumables	1	422.40	2	730.80
		4,599.68		4,524.67
Total		55,185.37		57,448.62

ECCE – extracapsular cataract extraction; RSD – Serbian dinars.

Moreover, the costs of complications are included in the analysis according to the administrative documentation for each patient with complications. The only exception was the cost of medicines used to treat corneal edema and macular edema, considering that the pharmacotherapy is applied at home.

Analysis

All calculations and analyses were performed using Microsoft Excel version 16 (Microsoft Corporation, USA, 2019). In cost-effectiveness analysis, results are presented as cost per patient without complications. An incremental cost-effectiveness ratio (ICER) analysis was also performed. To assess the robustness of the model, a one- and two-way sensitivity analysis was performed. The following variables were tested in the sensitivity analysis: the annual number of operations with the phacoemulsification method and the effectiveness of the technique itself.

Results

The results of the cost-effectiveness analysis are shown in Table 3. Considering all the costs included in the study, the total cost per patient in the phacoemulsification group was 71,008.70 RSD, while the total cost in the ECCE group was 74,340.36 RSD. Considering the method's effectiveness regarding the percentage of patients without complications, phacoemulsification shows higher effectiveness (87%) than the ECCE method (57%). Due to these findings, cost-effectiveness analysis shows that phacoemulsification is the dominant strategy compared to the ECCE method, meaning a technique with lower costs (-3,331.66 RSD) and higher effectiveness (0.3).

One-way sensitivity analyses were performed for an annual number of operations with the phacoemulsification method. The results were sensitive to this variable, where phacoemulsification stops being the dominant strategy if the number of operations drops below 350 per year. The two-

Table 3**Results of the cost-effectiveness analysis**

Technique	Effect	Δ effect	Cost (RSD)	Δ cost	ICER
ECCE	0.57		74,340.36		
Phacoemulsification	0.87	0.30	71,008.70	-3,331.66	Dominant (-11,105.53)

ECCE – extracapsular cataract extraction; ICER – incremental cost-effectiveness ratio; RSD – Serbian dinars.

way sensitivity analyses (number of operations and effectiveness of the phacoemulsification method) show that results were not sensitive to the effectiveness of the phacoemulsification method.

Discussion

According to the study results, phacoemulsification was more effective than the ECCE method due to a lower rate of complications (13% vs. 43%). That was similar to the Malaysian and Australian studies, with more common complications with the ECCE than the phacoemulsification technique¹¹⁻¹².

On the side of the costs, the results of our study show lower costs associated with phacoemulsification as a possible method of cataract surgery. A combination of higher effectiveness and lower costs results in the dominant status of phacoemulsification. Additionally, according to the analysis, the result is sensitive to the number of operated patients per year. Results from our study are comparable with those from Kara-Junior et al.¹³, which concluded a significant economic advantage in favor of the phacoemulsification technique, especially if the patient is working. A recent observational study from India showed similar results since phacoemulsification was found to be more cost-effective compared to other cataract techniques¹⁴. The study by Muralikrishnan et al.¹⁵ estimated the cost of different cataract surgery procedures by applying various perspectives. Contrary to our results, the authors revealed that phacoemulsification is associated with the highest costs assuming the same perspective as in our study, due to the need for expensive equipment and consumables. Identical results were obtained in India, where phacoemulsification had higher provider direct costs (25.55 USD) compared with ECCE (16.25 USD), which were attributed to the cost of equipment and consumables¹⁶.

The first published cost-effectiveness analysis revealed lower costs associated with ECCE compared to the phacoemulsification method in Australia¹⁷. The main reason for the difference in the results is that the authors assumed no difference between the two procedures based on expert opinion. Additionally, the authors concluded that any increase in the use of the phacoemulsification method results in decreasing costs, which is in line with our results.

Two studies conducted in Malaysia showed that the costs of phacoemulsification were higher than ECCE. A study from 2004 indicated no significant difference in cost-effectiveness between the two methods¹⁸, while a study from 2007 showed that ECCE is more cost-effective than phacoemulsification⁸. The difference with the results obtained in our study can be explained by the used unit of effectiveness. Namely, the studies used VA or vision-related quality of life evaluated by questionnaire.

The Cochrane Systematic Review from 2014 concluded that phacoemulsification results in better visual outcomes and a lower complication rate compared to ECCE. Still, the lower cost of ECCE may justify its use by maximizing the number of people that can be treated with restrained resources¹⁹.

Evidence from different settings suggests that cataract surgery is cost-effective in developing countries and Western countries, with the range of results from cost-utility analysis from 9 USD to 25,000 USD per quality-adjusted life year²⁰⁻²³. Similar results were obtained using the other type of outcome, disability-adjusted life year²⁴.

The results of our analysis support the use of phacoemulsification as a dominant surgical method in General Hospital Kruševac. The study results from Poland also revealed phacoemulsification as the preferred surgical technique for cataracts²⁵.

Although the pharmacoeconomic evaluation was introduced more than one decade ago into the Serbian health care system, its influence is humble and rather advisory, especially in other health technologies besides medicines, such as surgical or diagnostic procedures.

This economic evaluation has some limitations. The sample for the study was taken retrospectively, and it reflects current clinical practice with a disproportional number of techniques. Moreover, the analysis did not include the time needed for the surgeon phacoemulsification training program since all surgeons included in the analysis are senior, experienced surgeons. The inclusion of this variable would alter the results and conclusion since published studies show a high learning curve²⁶. The authors desired to perform a cost-utility analysis, but due to the unavailability of the patients, it was not possible to apply quality of life questionnaire to include humanistic outcomes in the study.

Conclusion

The phacoemulsification technique seems to be the preferred technique for cataract surgery based on the results of the pharmacoeconomic analysis. The study results justify the investment for phacoemulsification equipment and consumables if the number of surgeries per year in the health care institution is above 350. The phacoemulsification method in a healthcare institution is linked with clear economic and clinical outcomes, such as savings in monetary resources and a lower rate of complications.

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R E F E R E N C E S

1. *Nikolić Lj*. Cataract surgery. 1st ed. Belgrade: Zavod za udžbenike; 2009. (Serbian)
2. *WHO*. Blindness and vision impairment. Available from: <https://www.who.int/en/news-room/fact-sheets/detail/blindness-and-visual-impairment> [accessed 2021 April 21].
3. National Eye Institute. Cataract Data and Statistics. Available from: <https://www.nei.nih.gov/learn-about-eye-health/resources-for-health-educators/eye-health-data-and-statistics/cataract-data-and-statistics> [accessed 2021 April 21].
4. *Prokofjeva E, Wegener A, Zrenner E*. Cataract prevalence and prevention in Europe: a literature review. *Acta Ophthalmol* 2013; 91(5): 395–405.
5. *Hugosson M, Ekström C*. Prevalence and risk factors for age-related cataract in Sweden. *Ups J Med Sci* 2020; 125(4): 311–5.
6. *Institute of Public Health "Dr. Milan Jovanovic Batut"*. Selected health indicators for 2017. Belgrade: Institute of Public Health "Dr. Milan Jovanovic Batut"; 2018. (Serbian)
7. *American Academy of Ophthalmology*. Cataract in the Adult Eye Preferred Practice Pattern 2016. San Francisco, CA: American Academy of Ophthalmology; 2016.
8. *Manaf MRA, Aljunid SM, Annuar FH, Leong CK, Mansor N*. Cost-effectiveness analysis of cataract surgery with intraocular lens implantation: extracapsular cataract extraction versus phacoemulsification. *Med J Indones* 2007; 16(1): 25–31.
9. Assia-Pacific Association of Cataract & Refractive Surgeons (APACRS). Principles of Preferred Practice in Cataract Surgery. Available from: https://apacrs.org/ppp_cataract_EN/index.html#6
10. *Republic Health Insurance Fund*. Rulebook on prices of health services at the secondary and tertiary level. ("Sl. glasnik RS", br. 55/2019). (Serbian)
11. *Thevi T, Reddy SC, Shantakumar C*. Outcome of phacoemulsification and extracapsular cataract extraction: A study in a district hospital in Malaysia. *Malays Farm Physician* 2014; 9(2): 41–7.
12. *Clark A, Morlet N, Ng JQ, Preen DB, Semmens JB*. Whole population trends in cataract surgery over 22 years in Western Australia. *Ophthalmology* 2011; 118(6): 1055–60.
13. *Kara N Jr, Sirtoli MG, Santhiago MR, Parede TR, Espindola RF, Carvalho Rde S*. Phacoemulsification versus extracapsular extraction: governmental costs. *Clinics (Sao Paulo)* 2010; 65(4): 357–61.
14. *Rochmab TN, Wulandari A, Dablui M, Ernawaty, Wulandari RD*. Cost Effectiveness Analysis Using Disability-Adjusted Life Years for Cataract Surgery. *Int J Environ Res Public Health* 2020; 17(16): 6010.
15. *Muralikrishnan R, Venkatesh R, Prajna NV, Frick KD*. Economic cost of cataract surgery procedures in an established eye care centre in Southern India. *Ophthalmic Epidemiol* 2004; 11(5): 369–80.
16. *Agarwal A*. Measuring the cost-effectiveness of cataract surgery. Available from: <https://www.healio.com/news/ophthalmology/20120325/measuring-the-cost-effectiveness-of-cataract-surgery> [accessed 2022 February 03].
17. *Asimakis P, Coster DJ, Lewis DJ*. Cost effectiveness of cataract surgery. A comparison of conventional extracapsular surgery and phacoemulsification at Flinders Medical Centre. *Aust N Z J Ophthalmol* 1996; 24(4): 319–25.
18. *Loo CY, Kandiah M, Arumugam G, Gob PP, John E, Gurusami B*, et al. Cost efficiency and cost effectiveness of cataract surgery at the Malaysian Ministry of Health ophthalmic services. *Int Ophthalmol* 2004; 25(2): 81–7.
19. *de Silva SR, Riaz Y, Evans JR*. Phacoemulsification with posterior chamber intraocular lens versus extracapsular cataract extraction (ECCE) with posterior chamber intraocular lens for age-related cataract. *Cochrane Database Syst Rev* 2014; (1): CD008812.
20. *Griffiths UK, Bozzani FM, Gheorghe A, Mvenge L, Gilbert C*. Cost-effectiveness of eye care services in Zambia. *Cost Eff Resour Alloc* 2014; 12: 6.
21. *Agarwal A, Kumar DA*. Cost-effectiveness of cataract surgery. *Curr Opin Ophthalmol* 2011; 22(1): 15–8.
22. *Eye Care Comparative Effectiveness Research Team (ECCERT)*. *Hiratsuka Y, Yamada M, Akune Y, Murakami A, Okada AA, Yamashita H*, et al. Cost-utility analysis of cataract surgery in Japan: a probabilistic Markov modeling study. *Jpn J Ophthalmol* 2013; 57(4): 391–401.
23. *Lansingh VC, Carter MJ, Martens M*. Global cost-effectiveness of cataract surgery. *Ophthalmology* 2007; 114(9): 1670–8.
24. *Baltussen R, Sylla M, Mariotti SP*. Cost-effectiveness analysis of cataract surgery: a global and regional analysis. *Bull World Health Organ* 2004; 82(5): 338–45.
25. *Nowak MS, Grabska-Liberek I, Michalska-Matecka K, Grzybowski A, Kozioł M, Niemczyk W*, et al. Incidence and Characteristics of Cataract Surgery in Poland, during 2010-2015. *Int J Environ Res Public Health* 2018; 15(3): 435.
26. *Randleman JB, Wolfe JD, Woodward M, Lynn MJ, Chervenak DH, Srivastava SK*. The Resident Surgeon Phacoemulsification Learning Curve. *Arch Ophthalmol* 2007; 125(9): 1215–9.

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