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Economic evaluation of primary open-angle glaucoma

Avaliação econômica do glaucoma primário de ângulo aberto

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ABSTRACT

Objective: *To evaluate the cost-utility relation of the initial treatment with laser or primary open-angle glaucoma medications (PLA) in Brazil, considering on the one hand the total costs and on the other side the impact on patients' quality of life.* ***Methods:*** *The study was performed based on a Markov model, where a theoretical cohort of early-stage GPAA carriers was generated. The parameters used in the model were obtained in the literature and included: direct medical costs (consultations, examinations, treatment); direct non-medical costs (accommodation, transportation, meals, companions); indirect costs (related to incapacity for work); utility values (quality of life measured in QALY - quality-adjusted life year); and probability of transition between stages of health. Three treatment strategies were tested in the model: (1) without treatment; (2) initial treatment with eye drops; (3) initial treatment with laser trabeculoplasty. The measure of outcome was the incremental cost-utility ratio (RCUI). The robustness of the model was tested through sensitivity analysis.* ***Results:*** *The strategies (2) and (3) of the initial treatment of POAG generated gains in quality of life in relation to (1) in Brazil. Initiating the laser treatment generated an average gain of 1 QALY, whereas with medication it gave a gain of 2 QALYs on average. Among the three strategies tested, strategy (2) was cost-effective and was dominant over the other strategies, since it was at the same time the cheapest and the most effective strategy.* ***Conclusion:*** *Both laser trabeculoplasty and medications as primary treatments of early-stage POAG have generated significant gains in quality of life. The strategy of starting treatment with medications was cost-effective, whereas laser trabeculoplasty strategy was not cost-effective, when non-medical costs (direct and indirect) are included.*

Keywords: *Open-angle primary glaucoma/therapy; Laser treatment; Cost-effectiveness analysis, Quality of life*

RESUMO

Objetivo: Avaliar a relação custo-utilidade do tratamento inicial com laser ou medicamentos do glaucoma primário de ângulo aberto (GPAA) no Brasil, considerando de um lado os custos totais e de outro lado o impacto na qualidade de vida dos pacientes. **Métodos:** O estudo foi realizado com base em um modelo de Markov, onde uma coorte teórica de portadores de GPAA em estágio inicial foi gerada. Os parâmetros usados no modelo foram obtidos na literatura e incluíram: custos médicos diretos (consultas, exames, tratamento); custos não médicos diretos (gasto com hospedagem, transporte, alimentação, acompanhante); custos indiretos (relacionados à incapacidade para o trabalho); valores de utilidade (qualidade de vida medida em QALY – quality-adjusted life year); e probabilidade de transição entre os estágios de saúde. Três estratégias de tratamento foram testadas no modelo: (1) sem tratamento; (2) tratamento inicial com colírios; (3) tratamento inicial com trabeculoplastia a laser. A medida de desfecho foi a razão de custo-utilidade incremental (RCUI). A robustez do modelo foi testada através de análise de sensibilidade. **Resultados:** As estratégias (2) e (3) de tratamento inicial do GPAA geraram ganhos em qualidade de vida em relação à (1) no Brasil. Iniciar o tratamento com laser gerou ganho médio de 1 QALY, enquanto que com medicamentos propiciou um ganho de 2 QALYs em média. Dentre as três estratégias testadas, a estratégia (2) foi a custo-efetiva e foi dominante sobre as demais, pois foi ao mesmo tempo a mais barata e a mais efetiva. **Conclusão:** Tanto a trabeculoplastia a laser quanto os medicamentos como tratamentos primários do GPAA inicial geraram ganhos significativos de qualidade de vida. A estratégia de se iniciar o tratamento com medicações foi custo-efetiva, quando se considera os custos totais. A alternativa de tratamento inicial através de trabeculoplastia a laser não foi custo-efetiva.

Descritores: Glaucoma primário de ângulo aberto/terapia; Tratamento com laser; Análise de custo-efetividade; Qualidade de vida

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Introduction

In the world today, it is of great importance to know the costs related to a particular disease and its consequences. The economic impact of the blindness for the individual and the society is very huge.[1,2] Among the main causes of blindness in Brazil, we emphasize primary open-angle glaucoma (POAG), accounting for approximately 12% of causes of blindness. [3,4] Blindness by POAG, unlike other more frequent causes such as cataract and refractive errors, is irreversible.[5]

The impact of POAG in the patients' daily activities begins well before blindness finally appears. The quality of life of glaucoma patients is impacted in a variety of ways: from the type and cost of treatment to the progressive loss of sight, to a non-negligible psychological impact.[6]

The economic impact assessment of POAG shall include both medical and non-medical direct and indirect costs.[7] Some authors have already determined the costs related to glaucoma in several countries, including Brazil.[8-14] However, Brazilian data is still incipient.[7]

Among the main types of health economic evaluation studies, cost-utility studies are very important since they assess both the costs and impact on the quality and/or amount of life related to that pathology under study.[7] In Brazil, Guedes et al made a cost-utility evaluation for the treatment of POAG in 2016.[15] They had found that for patients with POAG in early stage both the strategy of initial treatment with laser trabeculoplastia and the strategy of initiating the treatment with eye drops were cost-effective under the perspective of the financier Brazilian Unified Health System (paying for the services). In the present study, the authors took into account only the direct medical costs, leaving aside non-medical costs (direct and indirect).[15]

Many patients and/or caregivers have to travel long distances to referral centers for glaucoma treatment. Therefore, non-medical costs such as transportation, accommodation, food, care giver, working days missed, social security benefits, etc. can have a significant economic impact.[16]

The objective of the present study was to carry out a cost-utility assessment of POAG from the society perspective, that is, taking into account on the one hand the total costs (medical, non-medical, direct and indirect), and on the other the impact on the quality of life of patients with POAG in Brazil.

Methods

The present research was carried out at Universidade Federal de Juiz de Fora, and it is a cohort of a bigger research project ongoing at said University, called the Economic Evaluation of Primary Open Angle Glaucome, and the approval at the Ethics Committee of UFJF was duly obtained under number 116/2010.

The present study consisted in evaluating a hypothetical population of patients with early-stage POAG (MD [mean deviation] index of the Humphrey perimetry > -6 dB) with the construction of an economic evaluation model. The age of entry into the model was 40 years. The Brazilian public health system (SUS) was used as the reference for this study.

The cost perspective was that of the society, that is, the total medical and non-medical, direct and indirect costs were taken into account.

The initial treatment alternatives for POAG analyzed in this study were: (1) no treatment; (2) initial treatment with eye drops (clinical treatment); (3) initial treatment with laser trabeculoplasty (laser treatment). The objective of including an alternative without treatment is to simulate one cohort of patients who remain without knowledge on the disease, and which POAG progresses without the patient taking any treatment. These patients do not have non-medical direct costs (transport, accommodation, feeding, etc), but have indirect costs (loss of productivity, disability, working days missed, both themselves and the care givers. Many will only diagnose glaucoma late in the progression of the disease, when blindness is virtually installed.

The study horizon was the average life expectancy of the Brazilian population, according to the Brazilian Institute of Geography and Statistics (IBGE). The cohort of hypothetical patients entered the model at age 40, and life expectancy was adjusted every year according to the IBGE life table. Both costs and effectiveness were discounted by 5%, as recommended by the Brazilian Ministry of Health.

For the analysis of the impact on quality of life, the values of utility for glaucoma patients in Brazil were taken into account, as described by Paletta Guedes et al.[17] These values were identified by the method Time Trade Off, from interviews with glaucoma patients in many progression periods of the pathology.

The direct medical costs were obtained from the perspective of SUS as the payer of services in the Reference Centers for the treatment of glaucoma in the public system. Included in this category are appointments, examinations, medications, surgeries, etc.

Non-medical direct costs (accommodation, food, displacement, caregivers) and indirect costs (loss of productivity) were obtained in a previous study by the same research group, including the costs of the patients' caregivers. In this previous study, monetary values were obtained in a cross-sectional study with interviews of glaucoma patients attending a SUS Reference Center for the treatment of glaucoma in the city of Juiz de Fora, in the state of Minas Gerais.

The costs of the interventions were extracted from the SUS table of medical procedures and fees. Frequencies of medical visits and examinations were obtained from what is established for the SUS Glaucoma Reference Centers. The price of the medicines was the amount paid by SUS to the Reference Centers.

In the alternative clinical treatment, the average number of eye drops per patient and the ratio of eye drops types at each evolutionary stage were obtained from the literature.

In the alternative laser treatment, laser trabeculoplasty was performed in both eyes in the first year. There was the possibility of a new application in each eye, if necessary (following the suggestion of Cantor et al, we add 21% in the cost of the initial trabeculoplastia to cover the costs of a possible new laser application).[18] In subsequent years, the literature costs of reintroducing eye drops to glaucoma were considered (50% of laser efficacy at the end of the year, i.e., 50% of patients without the need of eye drops, and 50% with the need for eye drops).[15] Adverse events of the laser were not taken into account in the costs due to the low incidence. The monetary values are in reais (R$) and refer to the year 2018.

A Markov model was built for the cost-utility analysis. The model had the following stages: (1) Initial glaucoma; (2) Moderate glaucoma; (3) Severe Glaucoma; (4) Blindness in the best eye; and (5) Death. Stage 1 (initial glaucoma) was the entry stage in the model, and stage 5 (Death) was the terminal stage. Every year, cohort members could stay at the same stage or progress to the next stage according to transition probabilities. Participants who progressed should follow the following pathway: Initial Glaucoma, Moderate Glaucoma, Severe Glaucoma, and Blindness, without skipping stages or returning to earlier stages. The transition probabilities between the stages for each alternative studied (observation, clinical treatment, and laser treatment) were taken from the literature.[15] Patients of any stage (1 to 4) could reach stage 5 (Death) without going through the other stages, according to the annual probability of death for the Brazilian population. The choice for Markov modeling was based on the characteristics of the pathology under study: a chronic disease with recurrent costs (chronic use of eye drops, medical visits, and examinations).

In the construction of the model, some assumptions were adopted. The duration of each cycle in the model was 1 year. The entire cohort was 40 years old, since it is from this age on that the prevalence of POAG begins to increase. In the clinical treatment strategy, the first line of treatment was performed with the use of prostaglandin analogues. In the event of failure to achieve the target intraocular pressure, the following eye drops were used: timolol maleate 0.5%, and dorzolamide hydrochloride 2%, following this sequence. This choice was based on the clinical experience of two of the authors (specialists in glaucoma), and also following the guidance of the Brazilian Glaucoma Society. In the strategy of laser treatment as initial therapy, the application of laser (selective trabeculoplasty) in 360° of trabeculae in both eyes during the first year was considered. If necessary, repetition of laser trabeculoplasty was allowed once again. In laser failure to control intraocular pressure, patients were reintroduced with hypotensive medication in the following sequence: prostaglandin analogue and timolol maleate 0.5%. No comparative economic study between eye drops and laser included laser complications. Studies using models are approximations of reality aiming to evaluate the average patient. Individual variabilities and rare complications are difficult to model. The probabilities of transition between the stages were fixed, that is, there were no adjustments in the probability with the progression of the model. Another assumption was that average utility values for each health condition (initial, moderate, severe glaucoma, and blindness) are not influenced by the type of treatment strategy.[15]

The outcome measure used in the present study was the incremental cost-utility ratio (ICUR) showing the incremental cost per benefit achieved (R$/QALY).

The robustness of the model was tested by the univariate sensitivity analysis using the Tornado diagram for the variables with the greatest impact on the result.

Data collection was carried out in Microsoft Excel 2010, and the cost-utility analysis was carried out on TreeAge Pro 2011 Health Care software (Tree Age Software, Williamstown, Massachusetts, USA).

Results

The parameters used in the construction of the Markov model are shown in Tables 1, 2 and 3. Table 1 shows the values of the different medical resources and their costs for SUS. The values of each type of cost (medical direct, nonmedical direct, and indirect) for each stage of the treatment model and strategy are set out in table 2. The values of utility used in this study are shown in table 3.

The final cost results for each treatment strategy of the POAG, the gains in quality of life, and the cost-utility ratio are shown in table 4.

The sensitivity analysis by the tornado diagram shows that the variable with the greatest impact on the model would be the age of entry (Figure 1), accounting for 96% of the model risk. Even so, redoing the model with different entry ages (50, 60 or 70) the result remained unchanged. Age only influences the outcome when the patients' entry occurs with values below 30 years, which is very rare for the POAG. The other parameters of the model (costs, utilities and transition probabilities) had little influence on the result, demonstrating the robustness of this result.

Table 1
Resources used and associated costs used in the model

Resouses	Frequency (months)	Code (SUS)*	Unit Value (R$)
Initial appointment[a]	12	03.01.01.010-2	57.74
Follow-up appointment[b]	3	03.03.05.001-2	17.74
Use of 1 medication[c]	3	03.03.05.005-5	127.98
Use of 2 medication[d]	3	03.03.05.018.7	146.64
Use of 3 medication[e]	3	03.03.05.022-5	226.02
Monoculat trabeculoplasty	Not applicable	04.05.05.012-7	45.00
New application of Trabeculoplasty[f]	Not applicable	04.05.05.012-7	9.45

* Code of the procedures table of the Brazilian Unified Health System (SUS), table SIGTAP (http://sigtap.datasus.gov.br/tabela-unificada/app/sec/inicio.jsp)

a. Initial appointment: includes complete ophthalmologic examination with tonometry, fundoscopy and campimetry.

b. Follow-up appointment: includes complete ophthalmologic examination with tonometry and fundoscopy.

c. Use of 1 medication of the type prostaglandin analogue

d. Use of 2 medications: prostaglandin analog + timolol maleate 0.5%

e. Use of 3 medications: prostaglandin analog + timolol maleate 0.5% + dorzolamide hydrochloride 2%

f. The cost of a new trabeculoplasty was included as a 21% increase in the cost of the first trabeculoplasty.

Discussion

The present study presents an unpublished result in the literature. The results of the present study demonstrate that the clinical treatment of POAG is cost-effective from a society perspective. In addition, this treatment strategy (initial clinical) is

Table 2
Cost of each evolutionary stage of glaucoma according to the treatment strategy

Treatment strategy	Stage of POAG	Direct medical cost (R$)	Direct medical non mical cost (R$)	Indirect cost (R$)	Total cost (R$)
Without treatment	Initial	0.00	0.00	20.156.75	20.156.75
	Moderate	0.00	0.00	26.988.16	20.156.75
	Severe	0.00	0.00	27.263.82	27.263.82
	Blindness	0.00	0.00	27.263.82	27.263.82
Clinical Treatment	Initial	909.61	587.47	20.156.75	21.653.83
	Moderate	969.08	660.52	26.988.16	28.617.76
	Severe	1.043.97	708.54	27.263.82	29.016.33
	Blindness	1.091.80	708.54	27.263.82	29.064.16
Laser Treatment: (First year)	Initial	547.12	587.47	20.156.75	21.291.34
	Moderate	547.12	660.52	26.988.16	28.195.80
	Severe	547.12	708.54	27.263.82	28.519.48
	Blindness	547.12	708.54	27.263.82	28.519.48
Laser Treatment: (Subsequent years)	Initial	438.22	587.47	20.156.75	21.182.44
	Moderate	438.22	660.52	26.988.16	28.086.90
	Severe	438.22	708.54	27.263.82	28.410.58
	Blindness	438.22	708.54	27.263.82	28.410.58

a) Clinical Treatment: Average annual cost based on:

- Initial annual appointment + 4 follow-up appointments + Eye drops needed for 1 year of treatment at SUS referral center
- Amount ratio of eye drops used at each evolutionary stage of glaucoma;
- Number of eye drops per year;
- Price of eye drops paid by SUS to the Reference Centers;
- Cost of adverse effects: Only costs associated with Asthma Crisis secondary to the inadvertent use of Beta-Blockers in these patients were included. Relative Risk = 2.29. There was an increase of 23.8% in the final average cost per patient.

b) Laser Treatment:

- First year counts for: 1 Initial appointment + 4 Follow-up appointments + Trabeculoplasty in 2 eyes + Eye drops necessary to complement the treatment + new trabeculoplasty.
- Subsequent years: 1 Initial appointment + 4 Follow-up appointments + Eye drops necessary to complement the treatment.
- Efficacy estimated at 50% at the end of the first year, i.e., 50% of patients without eye drops. The other 50% were divided as follows: 25% requiring prostaglandin analogs, and 25% requiring prostaglandin analog + timolol maleate 0.5%.
- The cost of repeating Trabeculoplasty was added at initial cost (21% more), according to a study by Cantor et al. 2008.
- Adverse events due to the use of timolol maleate 0.5% (Asthma crisis): A 23.8% increase in the average value of PG + Ti 0.5% was added.
- The cost was considered the same for all evolutionary stages of glaucoma.

Table 3
Average utility values for each stage (health condition) of the model[17]

Health conditions	Utility value
Initial glaucoma	0.8563
Moderate glaucoma	0.7966
Severe glaucoma	0.7512
Blindness	0.5700
Death	0.0000

Source: Paletta Guedes et al. [17]

Table 4
Total costs, utilities (Quality-adjusted life year – QALY) and cost-utility analys

Treatment strategy	Total Cost (R$)	Incremental Cost (QALY)	Effectiveness (QALY)	Incremental Effectiveness (QALY)	RCUI (R$/ QALY)
Clinical Treatment	384.549.36	***	13.89	***	***
Without Treatment	393.384.22	8.834.86	11.76	-2.13	Dominated
Laser Treatment	410.642.10	26.092.74	12.79	-1.1	Dominated

QALY: quality-adjusted life year; RCUI: Incremental cost-utility ratio.

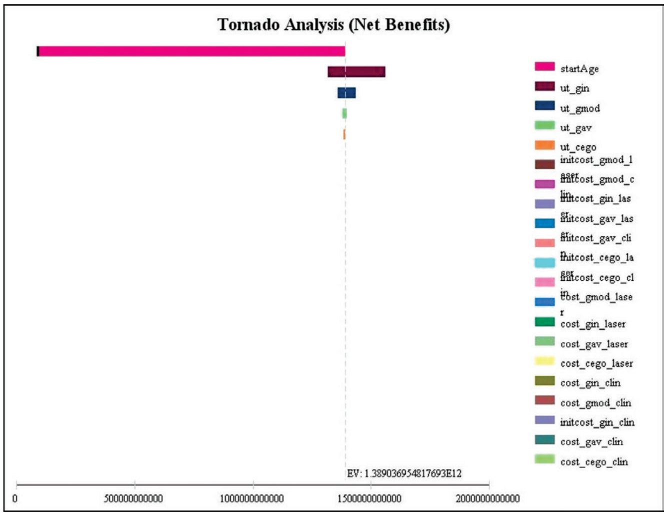

Figure 1: Sensitivity analysis by the Tornado Diagram

dominant over the other treatment strategy tested in the model: initial laser treatment. Clinical treatment is still dominant over non-treatment of POAG.

Cost-utility studies are important because they jointly assess the impact of costs and quality of life related to a given health intervention. According to the guidelines of the Ministry of Health, cost-effectiveness and cost-utility studies should be encouraged, as they aid in decision-making process by managers, physicians and patients.[7] Despite the scarcity of robust data for the studies of economic evaluation in health, the authors managed in an unpublished way to build a model to study this subject of great importance.

Brazil has developed a lot in the treatment of POAG with the public policy for glaucoma treatment. This government program created the Reference Centers for glaucoma treatment where patients can have care, follow-up, and treatment necessary for their disease.[10]

Guedes et al carried out a cost-utility analysis of POAG treatment from a SUS perspective, and found that for each evolutionary stage of glaucoma there is a more cost-effective treatment strategy.[8] In the early stages of POAG, both clinical treatment and laser treatment were cost-effective.[15] An important proviso is that the costs considered in the study by Guedes et al were only the direct medical costs. They reflect the impact of the costs for the Brazilian public health system (SUS) and its importance for the planning of resources destined to SUS.

In the present study, a model similar to that of Guedes et al was created with a significant change: the costs considered in the present study included direct non-medical costs and indirect costs in the analysis. The intent was to analyze the economic impact of glaucoma for society as a whole. The results show that when we include non-medical costs (direct and indirect), the cost-effectiveness situation changes a bit. The only cost-effective treatment becomes the clinical treatment, that is, it is more effective and cheaper when compared to laser treatment and non-treatment of POAG.

The results presented in this evaluation show that non-medical costs have an important social impact because they change an alternative (laser treatment) that was cost-effective from the point of view of the payer into a dominated alternative when the perspective changes to the total costs.

The results of gains in quality of life are worth discussing. The "non-treatment" strategy generates an average gain of 11.76 quality-adjusted life years (QALYs) per patient for the remainder of their life expectancy. Treating glaucoma with both strategies (eye drops or laser) generates significant gains in the quality of life measured in QALY. There is an average gain of 1.03 QALYs with the laser treatment strategy over non-treatment. The average gain was even higher with the clinical treatment: 2.13 QALYs. Therefore, there is a real gain in quality of life when POAG is identified and treated in the early evolutionary stages. QALY represents the one-year quality of life lived in perfect health.[7]

Quando se compara os ganhos em qualidade de vida entre as duas estratégias de tratamento, observa-se que o tratamento clínico gera em média 1,1 QALYs a mais em relação ao tratamento inicial com laser ao final da expectativa de vida média da população brasileira.

Clinical treatment is considered the reference alternative for the treatment of POAG, and was the most cost-effective because it was both cheaper and more effective than all the alternatives tested in the model. When the strategies evaluated have higher cost and lower effectiveness, there is no numerical result for the incremental cost-utility ratio. It is only said that the alternative analyzed was dominated. Both non-treatment of POAG and laser treatment were dominated by the reference treatment, which consists of starting with eye drops in the following order: prostaglandins, timolol maleate 0.5%, and dorzolamide hydrochloride 2%. These results can serve as the basis for establishing guidelines for SUS Reference Centers.

The results show acceptable robustness since most of the uncertainty of the model consists on the age of entry. The prevalence and incidence of POAG begins to increase in the general population after 40 years, the age chosen for entry into the model. The results were tested for different entry ages (30, 50, 60 and 70), and no significant changes were observed in the results. Laser tends to improve its cost-effectiveness in younger patients because it allows patients to spend some time with fewer eye drops of chronic use. From the age of 60 onwards (entry in the model), the strategy of "non-treatment of glaucoma" becomes a non-dominated alternative, but less cost-effective than the clinical treatment, without considering the possibility of ethical conflict of diagnosing a treatable disease and deciding not to treat.

Some limitations should be considered when analyzing the present results. The present study used a hypothetical population model, and had the scarce literature on the subject as data source. The model did not stratify patients according to risk factors for progression, such as race, thickness and biomechanics of the cornea, family history of blindness, perfusion pressure, etc. Like any model-based study, the results are influenced by the availability of data in the literature and the adoption of assumptions.

The possibility of resorting to anti-glaucomatous surgery in the event of failure of whatever initial treatment was not considered. Another fact that was not taken into account was adherence and persistence to treatment with eye drops. This can lead to an increase in the rate of progression of the disease, affecting the probabilities of higher transitions. The low adherence could be a source of cost error, because using less medication the bottle would last longer and the patient would buy fewer bottles. In the present study, this fact was not relevant since the cost perspective was that of SUS funding, so it did not matter if the patient used the medication or not, he would get a new bottle every 3 months. If the perspective of costs was that of the Supplementary or Private Health, the cost variations would happen among the regions of the Country limiting the study to the region of data collection.

The transition probabilities between health states of the models were obtained in the literature and come from multicenter clinical trials. It is known that in this type of study the results are often not the same as those obtained in daily clinical practice. Study patients are closely controled and monitored, which minimizes leakage and improves adherence and persistence. On the other hand, there are no real-life population studies showing the progression rate and outcomes of the natural history of glaucoma (treated versus untreated).

Finally, it is very important to be careful in generalizing the results of this study to patients with other types of glaucoma and those being treated in the supplementary health system or outside the reference centers of SUS for glaucoma treatment. As the non-medical costs were extracted in a survey in the city of Juiz de Fora - MG, generalization to other parts of Brazil may be limited.

This hypothetical cohort study demonstrates that the strategy of initiating treatment of initial POAG with medications was cost-effective when considering the total costs (medical and non-medical, direct and indirect) over a life expectancy horizon of the Brazilian population. The initial treatment alternative with the use of selective laser trabeculoplasty was not cost-effective. Both strategies showed important and significant gains in quality of life when compared to the strategy of not treating POAG.

References

1. Resnikoff S, Pararajasegaram R. Blindness prevention programmes: past, present, and future. Bull World Health Organ. 2001;79(3):222–6.
2. Rein DB, Zhang P, Wirth KE, Lee PP, Hoerger TJ, McCall N, et al. The economic burden of major adult visual disorders in the United States. Arch Ophthalmol. 2006;124(12):1754–60.
3. Sakata K, Sakata LM, Sakata VM, Santini C, Hopker LM, Bernardes R, et al. Prevalence of glaucoma in a South brazilian population: projeto Glaucoma. Invest Ophthalmol Vis Sci. 2007;48(11):4974–9.
4. Quigley HA, Broman AT. The number of people with glaucoma worldwide in 2010 and 2020. Br J Ophthalmol. 2006;90(3):262–7.
5. Weinreb RN, Khaw PT. Primary open-angle glaucoma. Lancet. 2004;363(9422):1711–20.
6. Guedes RA. Quality of life and glaucoma. Rev Bras Oftalmol. 2015;74(3):131–2.
7. Guedes RA, Guedes VM, Chaoubah A. Cost-effectiveness in glaucoma. Concepts, results and current perspective. Rev Bras Oftalmol. 2016;75(4):336–41.
8. Guedes RA, Guedes VM, Gomes CE, Chaoubah A. Maximizing cost-effectiveness by adjusting treatment strategy according to glaucoma severity. Medicine (Baltimore). 2016;95(52):e5745.
9. Philippe Nordmann J, Lafuma A, Berdeaux G. Modelling the lifetime economic consequences of glaucoma in France. J Med Econ. 2009;12(1):9–16.
10. Guedes RA, V.M. Growing costs in glaucoma: update and its impact in public health. Rev Atenção Prim Saúde. 2008;11(4):444-50.
11. Lee PP, Kelly SP, Mills RP, Traverso CE, Walt JG, Doyle JJ, et al.; Costs of Glaucoma Study Group. Glaucoma in the United States and europe: predicting costs and surgical rates based upon stage of disease. J Glaucoma. 2007;16(5):471–8.
12. Lee PP, Levin LA, Walt JG, Chiang T, Katz LM, Dolgitser M, et al. Cost of patients with primary open-angle glaucoma: a retrospective study of commercial insurance claims data. Ophthalmology. 2007;114(7):1241–7.
13. Lee PP, Walt JG, Doyle JJ, Kotak SV, Evans SJ, Budenz DL, et al. A multicenter, retrospective pilot study of resource use and costs associated with severity of disease in glaucoma. Arch Ophthalmol. 2006;124(1):12–9.
14. Traverso CE, Walt JG, Kelly SP, Hommer AH, Bron AM, Denis P, et al. Direct costs of glaucoma and severity of the disease: a multinational long term study of resource utilisation in Europe. Br J Ophthalmol. 2005;89(10):1245–9.
15. Guedes RA, Guedes VM, Gomes CE, Chaoubah A, Cost-utility of primary open-angle glaucoma in Brazil. Rev Bras Oftalmol. 2016;75(1):7–13.
16. Schehlein EM, Im LT, Robin AL, Onukwugha E, Saeedi OJ. Nonmedical out-of-pocket patient and companion expenditures associated with glaucoma care. J Glaucoma. 2017;26(4):343–8.
17. Paletta Guedes RA, Paletta Guedes VM, Freitas SM, Chaoubah A. Utility values for glaucoma in Brazil and their correlation with visual function. Clin Ophthalmol. 2014;8:529–35.
18. Cantor LB, Katz LJ, Cheng JW, Chen E, Tong KB, Peabody JW. Economic evaluation of medication, laser trabeculoplasty and filtering surgeries in treating patients with glaucoma in the US. Curr Med Res Opin. 2008;24(10):2905–18.

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