



Ambulatory and hospital care of glaucoma in Spain and associated medical costs

Josep Darbà^a  and Alicia Marsà^b 

^aDepartment of Economics, Universitat de Barcelona, Barcelona, Spain; ^bDepartment of Health Economics, BCN Health Economics & Outcomes Research S.L, Barcelona, Spain

ABSTRACT

Objectives: This study aimed to analyze the impact of glaucoma in ambulatory centers and hospitals in Spain over the past decade, in terms of incidence and medical costs.

Methods: Administrative data of glaucoma patients from ambulatory centers and hospitals in Spain and registered between 2011 and 2020 was obtained from a Spanish National discharge database. Medical costs obtained were based on the diagnosis-related group-based hospital payment systems, determined by the Spanish Ministry of Health.

Results: Data from 100,734 ambulatory care visits and 11,408 hospital admissions related to glaucoma were obtained from the database. Most of the cases were registered in patients over 65 years of age. The incidence of glaucoma in ambulatory centers was 2.2 per 10,000 persons over the study period; in hospitals, the incidence was 0.2 per 10,000 persons. The incidence of glaucoma in ambulatory settings increased significantly over the study period, while the incidence in hospitals decreased over the same period. Most ambulatory visits and hospital admissions were programmed or non-urgent. The mean cost per ambulatory visit was €954, €5.5 million in total annually; the mean cost per hospital admission was €3,727, €4.1 million in total annually. The annual cost of ambulatory care increased significantly over the study period, while the annual cost of hospital care decreased significantly.

Conclusions: The medical costs of glaucoma in Spanish hospitals decreased over the study period, while the costs of ambulatory care increased. This shift in the management of glaucoma should be considered in future resource allocation decisions.

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Introduction

Glaucoma is the main cause of irreversible blindness globally¹. Glaucoma comprises a group of disorders characterized by progressive degeneration of the optic nerve, with risk factors that comprise age, elevated intraocular pressure, non-white ethnicity and genetics^{2,3}. Preserving the patients' quality of life is crucial in the management of glaucoma. Current guidelines include recommendations for initial testing, patient monitoring and methods to decrease intraocular pressure. For instance, the European Glaucoma Society recommends prostaglandin analogues, selective laser trabeculoplasty and trabeculectomy as initial treatments in patients with mild or moderate open angle glaucoma². In addition, certain patients may require an alternative approach, such as glaucoma drainage implant surgery, a frequent procedure to place an artificial filtering device to lower intraocular pressure^{4,5}. Hence, the care of patients with glaucoma requires a combination of ambulatory surgery and follow-up and hospitalization for surgical treatment^{2,6}.

In 2013, the estimated prevalence of glaucoma in Europe among people aged 40–80 years was 2.9%, and long-term projections suggest that the number of people (aged 40–80 years) with glaucoma worldwide will increase over the next decade⁷.

Few data is available describing the epidemiology of glaucoma in Spain and the associated medical costs have not been evaluated at the national level. One study from a private Spanish hospital, centered on the hospital management of glaucoma, estimated a mean cost of €2,502 (US\$2,746) per patient with primary open-angle glaucoma between 2010 and 2013⁸. This study and many others demonstrate the association between disease severity and costs, however, ambulatory data in Spain is limited^{8,9}. To update disease incidence and cost evaluations is crucial to develop accurate cost-effectiveness evaluations of glaucoma screening and care, and to design related public health strategies. Consequently, the objective of this study was to analyze the impact of glaucoma in ambulatory centers and hospitals in Spain over the past decade, in terms of incidence and medical costs.

Methods

Study design

A retrospective database study was set to evaluate the burden of glaucoma in Spain from a payer perspective. With this aim, administrative data corresponding to ambulatory

CONTACT Josep Darbà  darba@ub.edu  Department of Economics, Universitat de Barcelona, Diagonal 696, Barcelona, 08034, Spain

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visits and inpatient hospital admissions was analyzed, and obtained from a Spanish National discharge database. This database covers 90% of hospitals in Spain and includes data from all Spanish regions. Data is codified at the hospital level using the International Statistical Classification of Diseases and Related Health Problems, the 9th version (ICD-9) before 2016 and the 10th version (ICD-10) after the year 2016^{10,11}. The Spanish Ministry of Health is responsible for data validation and elimination of errors and unreliable data.

Data extraction

The ICD-9 and ICD-10 codes corresponding to glaucoma (365 and H40) were used to claim records of ambulatory and hospital admissions in which glaucoma was registered as the admission motive (primary diagnosis). The inclusion period was from 1 January 2011 to 31 December 2020. There were no parameters identifying healthcare centers or medical history, all files were previously re-coded to maintain anonymity in accordance with the principles of Good Clinical Practice and the Declaration of Helsinki. No human participants were involved and there was no access to identifying information; in this context, patient consent and ethics committee approval are not required¹².

Study variables

The parameters obtained for hospital admissions included: patients' age, date of admission, type of admission, date of discharge, type of discharge, primary diagnosis, up to 20 secondary diagnoses registered during the admission, medical procedures and cost. For ambulatory visits data obtained included: age groups, date of admission, type of admission, primary diagnosis and cost.

Data analysis

Patients diagnosed with glaucoma were identified by the primary diagnosis code. Patients' were classified by sex and into four age groups. The first admission registered per patient was used to evaluate patient characteristics, whereas

all files were used to analyze admission details and medical costs. Incidence was calculated as the admission/hospitalization rate based on the admissions registered in the database. This corresponded to the number of patients with glaucoma registered in Spanish ambulatory centers per population assigned, and the number of patients with glaucoma registered in Spanish hospitals per population assigned.

Direct medical costs were obtained from the database, where they are assigned according to the standardized average expenses of admissions and medical procedures determined by the Spanish Ministry of Health. These costs comprise all expenses related to the admission: medical examination and procedures, medication, surgery, diet, costs associated with personnel, medical equipment and resources. Costs were adjusted for inflation to 2020 values.

The Kolmogorov-Smirnov test was used to test for normality. Frequencies and percentages are presented for dichotomous variables and mean or median were calculated for continuous variables. Two-tailed non-parametric independent *t*-test (Mann-Whitney *U* test) or one-way analysis of variance (Kruskal-Wallis test) were used as appropriate and two-sample *Z* tests were used to test for differences in sample proportions. The Jonckheere–Terpstra trend test was used to assess trends in incidence and cost. A $p < .05$ was considered statistically significant.

Microsoft Excel® Professional Plus 2016 (Microsoft Corporation, Redmond, WA, USA) and StataSE 12 for Windows (StataCorp LP. 2011. Stata Statistical Software: Release 12. College Station, TX, USA) were used to perform statistical analyses.

Results

Over the study period, 100,734 ambulatory care visits were registered due to glaucoma (Table 1). During the same period, 11,408 hospital admissions were registered due to glaucoma. In both settings, most of the cases were registered in patients over 65 years of age, and there were significantly more males than females ($p < .0001$). The most frequent comorbid conditions registered in hospital centers were essential hypertension (21%), cataract (19%), diabetes mellitus (16%) and hyperlipidemia (11%).

Table 1. The number of ambulatory visits and hospital admissions registered between 2011 and 2020 by sex and age.

	Total	Males	Females
Ambulatory care, <i>N</i>	100,734	51,903	48,825
≤14 years, <i>N</i> (%)	1,511 (1.5)	799 (1.5)	732 (1.5)
15–44 years, <i>N</i> (%)	5,037 (5.0)	3,062 (5.9)	1,953 (4.0)
45–64 years, <i>N</i> (%)	24,277 (24)	13,962 (27)	10,253 (21)
≥65 years, <i>N</i> (%)	69,909 (69)	34,100 (66)	35,886 (74)
Hospitalization, <i>N</i>	11,408	5,959	5,449
≤14 years, <i>N</i> (%)	3,727 (3.7)	1,869 (3.6)	1,221 (2.5)
15–44 years, <i>N</i> (%)	9,066 (9.0)	5,190 (10)	3,808 (7.8)
45–64 years, <i>N</i> (%)	28,407 (28)	16,090 (31)	13,183 (27)
≥65 years, <i>N</i> (%)	59,433 (59)	28,702 (55)	33,982 (70)
Comorbid conditions:	–	–	–
Essential hypertension, <i>N</i> (%)	20,751 (21)	10,173 (20)	10,595 (22) [$p = .0352$]
Cataract, <i>N</i> (%)	18,938 (19)	9,446 (18)	9,472 (19)
Diabetes mellitus, <i>N</i> (%)	15,715 (16)	8,824 (17)	6,884 (14) [$p = .0015$]
Hyperlipidemia, <i>N</i> (%)	10,980 (11)	5,450 (11)	5,517 (11)

Notes: Patients' age did not follow a normal distribution. Two-sample *Z* tests were used to test for differences in sample proportions. *P*-value: males vs. females, only when significant ($p < .05$ considered statistically significant).

The incidence of glaucoma in ambulatory settings was 2.2 per 10,000 persons between 2011 and 2020; in hospitals, incidence was 0.2 per 10,000 persons. The incidence of glaucoma in ambulatory settings increased significantly over the study period ($p = .0029$ in males, $p = .0490$ in females), while the incidence in hospitals decreased over the same time period ($p = .0032$ in males, $p = .0149$ in females) (Figure 1).

Most of the ambulatory visits (99%) were registered in ophthalmology departments and were programmed or non-urgent (96%). Most of the hospital admissions (96%) were registered in ophthalmology departments and were programmed or non-urgent (76%). The median length of

hospital stay was 2 days, with no significant differences between males and females or by age (Table 2). The most frequent medical procedures registered at the hospital level were associated with surgical drainage procedures, while cataract-related surgeries were also registered.

The mean cost per ambulatory visit was €954 over the study period, whereas the mean cost per hospital admission was €3,727 (Table 3). No significant differences were observed in the cost of ambulatory or hospital admissions by sex or age.

Ambulatory visits represented a total annual cost of €5.5 million, €2.8 for males and €2.6 for females (Figure 2a). The total annual cost of hospital care was €4.1 million, €2.2 for males and €2.0 for females. Similarly to what was observed in incidence rates, the annual cost of ambulatory care increased significantly over the study period ($p = .0011$ in males, $p = .0088$ in females), while the annual cost of hospital care decreased significantly ($p = .0268$ in males, $p = .0268$ in females) (Figure 2b).

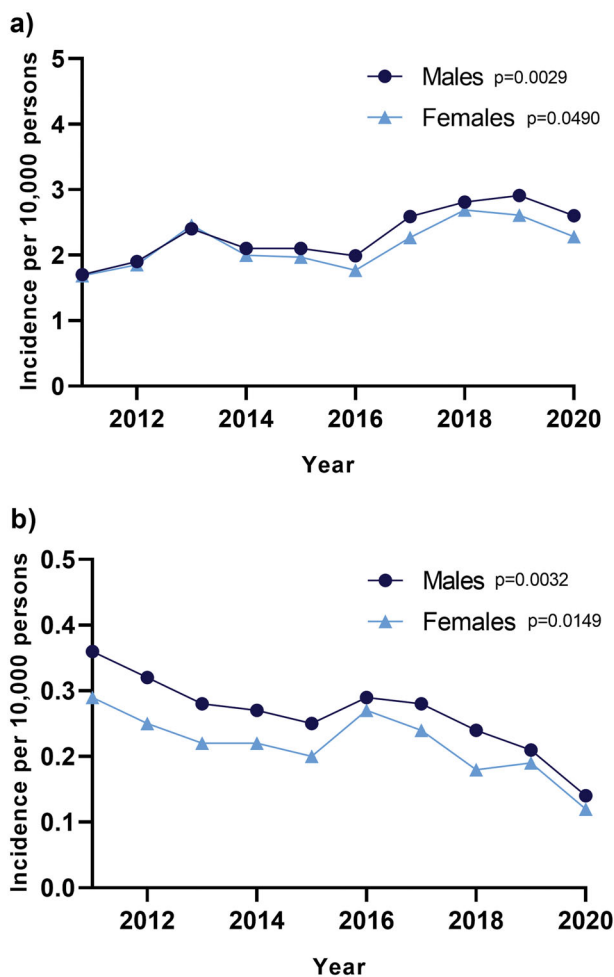


Figure 1. Incidence (admission/hospitalization rate) of glaucoma measured in ambulatory settings (a) and hospitals (b) per year in Spain. The Jonckheere–Terpstra trend test was used to assess temporal trends.

Discussion

Glaucoma is a chronic condition that can be associated with significant healthcare costs as the disease advances⁹. This study aimed to evaluate the incidence and costs of glaucoma in Spain both in ambulatory and hospital settings. The majority of patients included in the study were men over 45 years of age. Incidence in ambulatory settings was 2.2 per 10,000 persons, increasing significantly over the past decade, whereas the incidence registered in hospital settings was 0.2 per 10,000 persons, decreasing significantly during the same time period. Glaucoma requires multi-dimensional treatment,

Table 3. Mean medical costs of ambulatory care and hospitalization by sex and age group.

	Total	Males	Females
Mean ambulatory visit cost, €	954	953	954
≤14 years, €	973	975	971
15–44 years, €	950	952	947
45–64 years, €	950	949	951
≥65 years, €	955	955	955
Mean hospitalization cost, €	3,727	3,731	3,723
≤14 years, €	3,708	3,838	3,570
15–44 years, €	3,792	3,719	3,883
45–64 years, €	3,708	3,716	3,697
≥65 years, €	3,728	3,732	3,723

Notes: Cost did not follow a normal distribution. Two-tailed non-parametric independent *t*-tests (Mann-Whitney *U* test) were used to test for differences between groups.

Table 2. Characteristics of hospital admissions.

	Total	Males	Females
Median length of stay, days (IQR)	2 (2)	2 (2)	2 (2)
Medical procedures:	–	–	–
Scleral fistulization, <i>N</i> (%)	63,160 (63)	33,477 (66)	29,686 (61) [$p = .0002$]
Other procedures for relief of elevated intraocular pressure ^a , <i>N</i> (%)	11,685 (12)	6,125 (12)	5,517 (11)
Insertion of prosthetic lens, <i>N</i> (%)	18,334 (18)	9,446 (18)	8,886 (18)
Extracapsular extraction of lens by fragmentation and aspiration technique, <i>N</i> (%)	15,506 (14)	7,370 (14)	7,080 (15)
Operations on vitreous, <i>N</i> (%)	9,368 (9.3)	5,242 (10)	4,101 (8.4)
Facilitation of intraocular circulation, <i>N</i> (%)	6,346 (6.3)	3,529 (6.8)	2,832 (5.8) [$p < .0001$]

Notes: Length of stay did not follow a normal distribution. Two-sample *Z* tests were used to test for differences in sample proportions. *P*-value: males vs. females, only when significant ($p < .05$ considered statistically significant). ^aProcedures including cyclodiathermy, cyclocryotherapy, cyclophotocoagulation and the diminution of ciliary body.

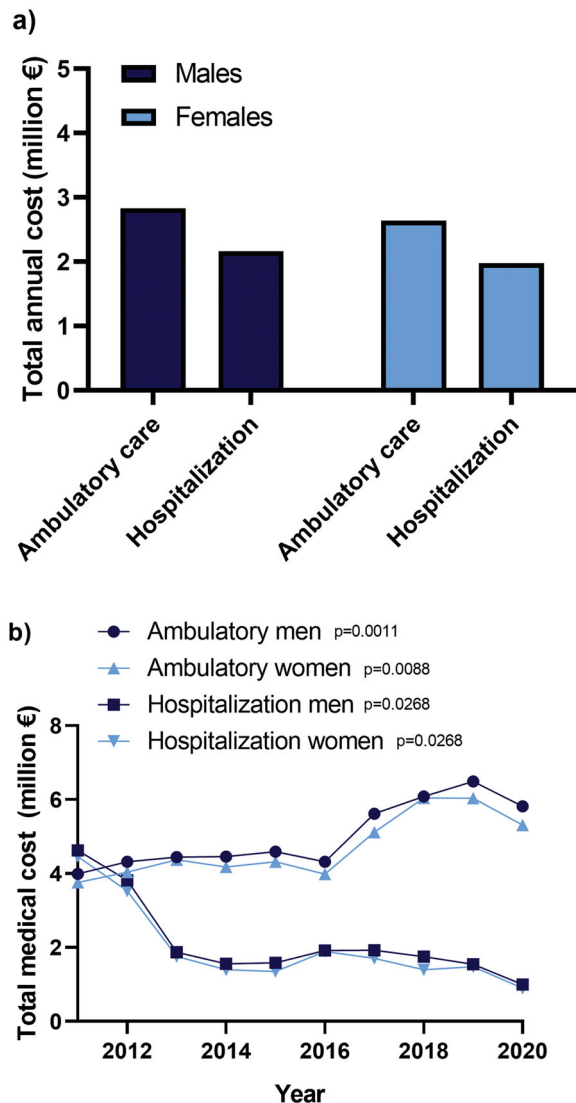


Figure 2. Mean annual direct medical cost (a) and medical cost per year (b). Costs included medical examination and procedures, medication, surgery, diet, costs associated with personnel, medical equipment and resources; the Jonckheere–Terpstra trend test was used to assess temporal trends.

integrating pharmacological and surgical interventions^{2,13}. Data evaluated herein suggests a shift in disease management over the past decade. Further studies will be required to evaluate drug prescriptions and procedures that did not require hospitalization, not registered in this database. In hospital settings, the registered admissions were principally associated with invasive surgical procedures aimed at relieving elevated intraocular pressure, with a median length of stay of 2 days. In addition, a number of patients received cataract-related surgeries, which could be associated with a previous glaucoma surgery¹⁴.

In terms of medical costs, the mean cost per ambulatory visit in this study was €954, while the mean cost per hospital admission was €3,727. In this context, it could be argued that favoring outpatient/ambulatory procedures versus overnight surgical care could contribute to reducing the total burden of glaucoma; one option to advance in this direction would be the elimination of payments to hospitals for overnight glaucoma surgical care. Nevertheless, the lack of

disease severity data in this study limits results in interpretation in this aspect. Additionally, another factor that could contribute to reducing the burden of glaucoma would be diminishing the costs linked to systemic comorbid conditions, such as hypertension, diabetes and hyperlipidemia.

The annual cost of glaucoma in this study summed at €9.6 million when considering ambulatory and hospital care. Earlier evaluations in the United States and several European countries estimated a cost per patient of €455–568 per year in the early stages of glaucoma, and €969–2,290 in end-stages, suggesting that an earlier diagnosis and treatment of glaucoma can reduce the burden of this disorder, however, evidence in this direction is limited^{15,16}. Overall, the cost-effectiveness of glaucoma screening has been repeatedly evaluated. Although screening for glaucoma was cost-effective in rural and urban Chinese regions in a 2019 study, a systematic meta-analysis deemed population screening not cost-effective^{17,18}. Further studies will be required, with the introduction of new treatment options, to evaluate the cost-effectiveness of glaucoma screening and management.

Several limitations may have influenced the results of this study. Disease severity was not registered and prescription medication could not be evaluated. Similarly, ambulatory medical procedures were not registered in the database limiting the analysis of disease management. These restrictions hampered the analysis of cost drivers; however, mean and total costs were calculated independently, which ensures the reliability of economic data.

Conclusions

The medical costs of glaucoma registered in Spanish hospitals decreased over the study period, while the portion of costs associated with ambulatory care increased, reflecting a shift in the management of this disorder. The introduction of new therapeutic methodologies, favoring ambulatory care, should be considered in future resource allocation decisions.

Transparency

Declaration of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of financial and other interest

The authors declare that they have no competing interests.

Peer reviewers on this manuscript have no relevant financial or other relationships to disclose.

Author contributions

JD contributed to the investigation by analyzing and interpreting the burden associated to glaucoma in Spain and was a major contribution in the intellectual content revision. AM analyzed the current situation of glaucoma in Spain, interpreted the statistical data and was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

Data availability statement

Data sharing is restricted due to legal stipulations, yet the data that support the findings of this study is fully available from the Spanish Ministry of Health via the Unit of Health Care Information and Statistics (Spanish Institute of Health Information) for researchers who meet the criteria for access to confidential data at: <https://www.msccs.gob.es/estadEstudios/sanidadDatos/home.htm>.

Ethics approval and consent to participate

Ethics committee approval and consent were not required for this study.

ORCID

Josep Darbà  <http://orcid.org/0000-0003-2371-0999>

Alicia Marsà  <http://orcid.org/0000-0001-8116-7029>

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