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Assessing the economic burden of vision loss and irreversible legal blindness in Spain (2021–2030): a societal perspective

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Abstract

Objective To estimate the economic impact for the society, generated as a consequence of the onset of loss of vision and irreversible legal blindness, for the main ophthalmologic diseases in Spain: glaucoma, diabetic retinopathy (DR), diabetic macular edema (DME), age-related macular degeneration (AMD) and high myopia (HM).

Methods A cost analysis model was developed to estimate the economic burden of glaucoma, DR, DME, AMD and HM over a 10-year time horizon (2021-2030), from a societal perspective in Spain.

The epidemiological and economic parameters used in the model were obtained through a literature review. Prevalence, incidence, and progression stages were used to establish the epidemiological flows. Annual costs per patient from publications were included and classified into direct healthcare, direct non-healthcare and indirect costs. Costs from other countries were converted based on purchasing-power-parity (€EUR, PPP). Epidemiological parameters about population and cost results were validated by a panel of experts.

All costs were adjusted to euros, 2021 (€, 2021), and using the Consumer Price Index (CPI) of the last 10 years, extrapolated to 2030 euros (€, 2030).

Results It was estimated that the total population of patients with the main diseases pathologies (glaucoma, DR, DME, AMD and HM) will increase to 7.99 million patients by 2030, representing an increase of 103%.

The total cost by 2030 of all pathologies would amount to 99.8 billion euros. Direct non-healthcare costs account for the largest item (44%), followed by loss of productivity costs (38%), and direct healthcare costs (18%). The pathologies with the highest cumulative costs will be glaucoma (€33.6 billion) and DME (€19.8 billion).The greatest increment costs compared to 2021 will likely be generated by pathologies related to diabetes mellitus, such as DR (703%) and DME (317%).

Conclusions Knowing the costs associated with the pathologies that generate loss of vision and irreversible legal blindness is essential to understand the socioeconomic impact associated with these pathologies. Furthermore, the high cost of treating these diseases makes necessary to coordinate efforts between administrations, together with the support of patient associations, to meet their needs.

Keywords Blindness, Cost, Epidemiology, Visual Impairment, Spain

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Introduction

The loss of visual acuity (VA) because of an eye condition is of great concern worldwide, especially when it is linked to vision loss and/or blindness. It is estimated that around 2.2 billion people suffer from impaired vision, and in 50% of cases, the loss of vision could have been prevented [1]. Visual limitation depends on many factors, including the availability of interventions and treatments and access to vision rehabilitation. In Spain, according to the latest data estimates from the Spanish National Health Survey, 13.4% of the population over 15 years of age suffers from some type of visual limitation, of which 11.6% have moderate vision limitation, and 1.9% have severe or complete vision loss [2].

There are several eye diseases that can lead to blindness or vision loss and are associated with multiple factors. Among these factors, ageing and the increase in chronic diseases such as diabetes mellitus (DM) are the main risk factors. In Europe [3, 4], and particularly in Spain, the main ophthalmological diseases that cause vision loss and blindness are glaucoma, diabetic retinopathy (DR), diabetic macular edema (DME), age-related macular degeneration (AMD), and high myopia (HM) [5].

People with visual impairment have lower Health-Related Quality of Life (HRQoL) scores [6–8].Indeed, vision loss and blindness are associated with an increased risk of falls and accidents, and with higher rates of depression and anxiety [9–12]. Moreover, these patients often suffer from problems in social settings due to the difficulties they find in accessing buildings, transport and information.

In addition to a reduction in the quality of life of these patients, vision loss and blindness generate a high economic burden for both, Health Systems and Society [13–16]; mainly due to the direct non-healthcare costs generated by the need for informal care and the acquisition of devices and adaptations for daily life [5, 17], which can account for up to 80% of the cost [15]. Vision loss and blindness can significantly impact employment rates and loss of productivity. Studies have found that individuals of working age with low vision or blindness experience a higher loss of productivity due to unemployment and incapacity to work than the general population [13, 14, 18, 19]. However, there is a lack of research on the long-term economic burden experienced by patients with the main vision loss and blindness-causing conditions in Spain.

Therefore, the aim of this analysis has been to estimate the economic burden that the appearance of vision loss and irreversible legal blindness generates on society due to the main ophthalmological diseases in Spain.

Methods

A cost analysis model was developed in Microsoft Excel® to evaluate the economic burden produced by the leading causes of irreversible visual loss and legal blindness in patients in Spain, including glaucoma, DR, DME, AMD and HM, according to the *National Organization of the Spanish Blind* (ONCE) [20] (Fig. 1 and Additional file 1).

To achieve this, a literature review was conducted to obtain epidemiological parameters and cost data for the diseases, which were then used to establish the parameters for the model. For the validation of the parameters identified during the literature review, an online session was held to obtain feedback from experts in ophthalmology, hospital pharmacy, representatives of associations of patients with visual limitations due to diseases such as glaucoma and AMD, and health administration managers of different Autonomous Communities.

Literature review

The literature review was performed in the electronic database Medline (PubMed) and was complemented with a search of other sources, such as ScienceDirect, Google Scholar, and medical societies. The search was conducted from the inception until April 2020, using the following terms: "blindness", "vision," "low", "vision, ocular", "epidemiology", "incidence", "prevalence", "cost", "economics", "cost analysis", "burden", "macular degeneration", "diabetes complications", "glaucoma", "refractive errors", "cataract", "burdened", "burdening", "macular degeneration", "high myopia", "diabetic retinopathy", "macular edema", "cost", "economics", "cost analysis", using Boolean terms (OR, AND).

The eligibility of studies was first assessed according to the title and abstract, followed by full-text screening considering pre-determined inclusion and exclusion criteria. Inclusion criteria used were publications in English or Spanish, with an adult population, articles with epidemiological data from Spain or European countries, or with costs in euros. Exclusion criteria included articles written in a language other than English or Spanish, with a paediatric population, not including epidemiological data or costs of the disease. Cost-effectiveness or cost-utility studies of a treatment or reporting very outdated epidemiological or cost data and publications with costs in a currency other than the euro were also excluded (Additional file 2).

Cost analysis

To evaluate the costs associated with five representative diseases (glaucoma, DR, DME, AMD, and HM), a ten-year time horizon was designated, spanning from 2021 to 2030 (Fig. 1). To obtain a comprehensive view of the burden of these diseases, the analysis was conducted from the perspective of the Spanish society. This approach incorporated direct healthcare costs, direct non-healthcare costs, and loss of productivity.

To estimate the cost of each eye disease, the number of individuals affected by the pathologies between 2021 and

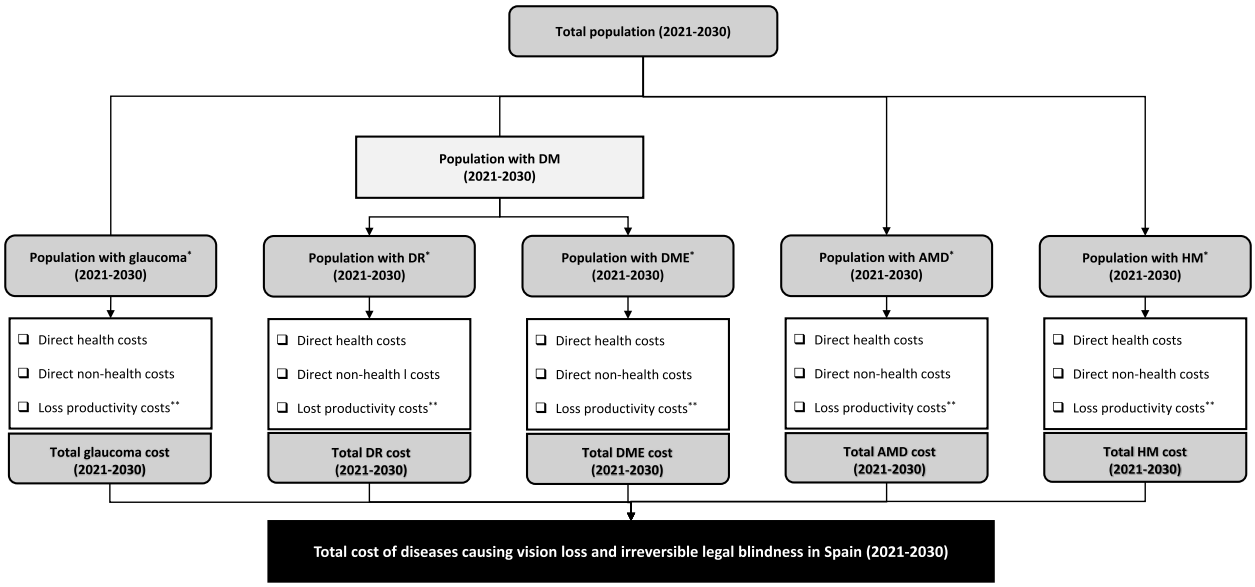


Fig. 1 Structure of the model of population variation and financial impact of the most important diseases that cause loss of vision and irreversible legal blindness in Spain from 2021 to 2030. *For more information on how patients with each pathology were calculated, please refer to the following Additional file 3. **The calculation of loss productivity was restricted to individuals who are considered part of the active population, that is, those who are over 18 years of age and under 65 years of age. AMD: age-related macular degeneration; DME: diabetic macular edema; DR: diabetic retinopathy; HM: high myopia

2030 was calculated. The individual cost of each disease was then assessed by reviewing the literature and multiplied by the number of individuals affected.

Population

An epidemiological flow was established to determine, for each of the diseases, the susceptible population in Spain (Additional file 3). This flow started considering the general population in Spain above the age of onset of the disease. For DR, DME, and HM, all the adult population (≥18 years) was considered, resulting in a cohort of 39,154,892 inhabitants [21]. However, glaucoma and AMD are developed at later ages. Glaucoma has an onset age of ≥40 years, while AMD has an onset age of ≥65 years, resulting in a total population of 27,340,183 and 9,397,961 of persons, respectively, according to data from the National Institute of Statistics (INE) [21].

As a second step, the epidemiological characteristics of each disease were applied to the general population. The prevalence was applied to the population of the first year (2021), while the incidence was applied to the population of the following years (2022-2030) [22]. Afterwards, the population was differentiated according to severity (mild, moderate, or severe) or subtype of the disease (Table 1).

The calculation of the population susceptible to glaucoma was determined by applying a prevalence rate of 4.5% [23] for the primary form of open-angle glaucoma (POAG) and 0.4% [24] for angle-closure glaucoma (PACG). In the absence of published evidence on incidence, an estimate was made using the prevalence rates of POAG and PACG and population growth between the ages of 40-100 years. This assumption was validated by the expert panel. The proportions of early, intermediate and advanced glaucoma for POAG were applied based on the experience of the expert panel, which is 80%, 15% and 5% respectively (Table 1 and Online Fig 2).

In patients with DM and DR, the diabetic population was previously determined by DM subtype, type 1 (DM1) or type 2 (DM2) and adjusted for DM-related mortality [25] before application of prevalence and incidence [26–28]. In patients with DR the prevalence and incidence rates were applied for each of the forms: mild non-proliferative (mild NPDR), moderate non-proliferative (moderate NPDR), severe non-proliferative (severe NPDR) and proliferative (PDR). These rates were applied for each of the types of diabetes (DM1 and DM2) [27, 29, 30]. In DME patients, prevalence and incidence rates were applied for patients with DM1 and DM2 [30, 31] (Table 1, Online Fig 3 and Online Fig 4).

The population susceptible to AMD was stratified according to age and progression (early, intermediate and advance [dry and wet]) [32, 33] (Table 1 and Online Fig 5). Finally, in patients with HM, prevalence and incidence rates, as well as the proportion of patients suffering from the neovascular disease [34] (Table 1 and Online Fig 6).

Table 1 Parameters used to estimate populations and their costs

Pathologies			Prevalence	Incidence
Glaucoma		***POAG***	4.50% [23]	0.10%[a]
		PACG	0.40% [24]	0.01%[a]
Diabetic retinopathy (DR)	***DM1***	***Mild NPDR***	7.06% [27]	7.05%[b] [31]
		Moderate NPDR	7.59% [27]	1.06%[b] [31]
		Severe NPDR	2.87% [27]	0.75%[b] [31]
		PDR	1.02% [27]	0.13%[b] [31]
	DM2	***Mild NPDR***	12.03% [30]	7.05%[b] [31]
		Moderate NPDR	5.09% [30]	1.06%[b] [31]
		Severe NPDR	1.50% [30]	0.75%[b] [31]
		PDR	0.56% [30]	0.13%[b] [31]
Diabetic macular edema (DME)		**DM1**	10.06% [27]	2.30%[c] [54] 2.00%[c] [54]
		DM2	10.30% [27]	1.40%[c] [54] 2.40%[c] [54]
Age-related macular degeneration (AMD)	***Early***	**65-69 years**	0.1% [33]	0.8%[d] [32]
		70-74 years	2.4% [33]	1.8%[d] [32]
		75-79 years	2.6% [33]	3.9%[d] [32]
		≥ 80 years	3.1% [33]	6.8%[d][32]
	Intermediate	**65-69 years**	0.1% [33]	0.8%[d] [32]
		70-74 years	0.1% [33]	1.8%[d] [32]
		75-79 years	0.4% [33]	3.9%[d] [32]
		≥ 80 years	0.7% [33]	6.8%[d] [32]
	Wet	**65-69 years**	0.7% [33]	0.3%[d] [32]
		70-74 years	1.8% [33]	1.3%[d] [32]
		75-79 years	2.4% [33]	2.5%[d] [32]
		≥ 80 years	8.5% [33]	3.6%[d] [32]
	Dry	**65-69 years**	0.2% [33]	0.5%[d] [32]
		70-74 years	0.4% [33]	0.6%[d] [32]
		75-79 years	1.9% [33]	1.4%[d] [32]
		≥ 80 years	4.1% [33]	3.2%[d] [32]
High myopia (HM)			3.0% [34]	0.3% [34]

DM1 diabetes mellitus type 1; *DM2* diabetes mellitus type 2; *NPDR* non-proliferative diabetic retinopathy; *PDR* proliferative diabetic retinophaty; *PACG* primary angle closure glaucoma; *POAG* primary open angle glaucoma

[a] Estimated value by means of growth of the population and prevalence values

[b] Incidence in patients with DR (type of DM not specified)

[c] Incidence rates were different between years 1-4 and 4-10 of follow-up according to Romero-Aroca et al., 2005 [54]

[d] Data per 1000 people/year

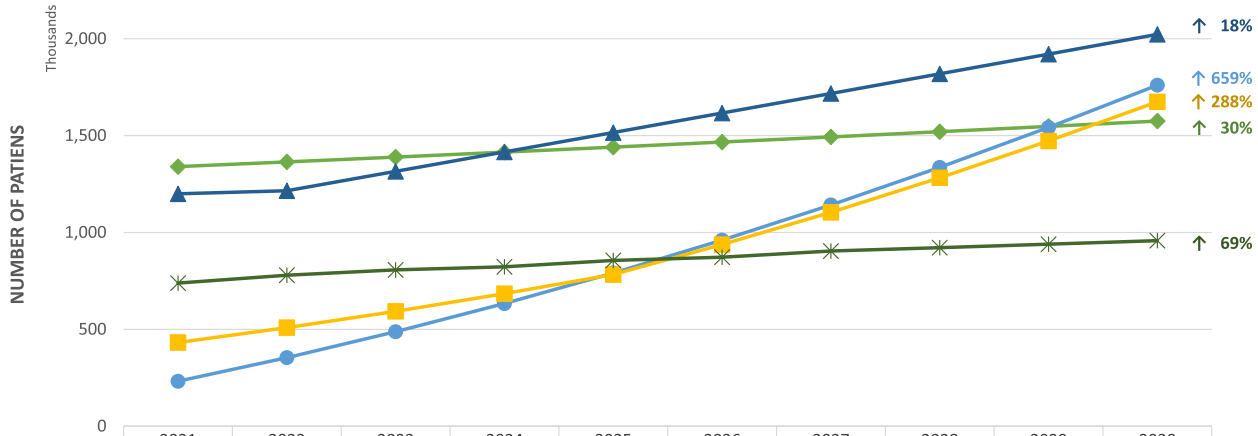
Resources and costs

To the burden of the analysed pathologies, was estimated using the annual consumption of resources related to direct healthcare, direct non-healthcare, and indirect costs per patient, which were obtained from the literature and consensus reached by the panel of experts (Table 2).

Direct healthcare costs were defined as those expenses that directly arise from the management of the diseases in the healthcare setting. These include consultations, diagnostic and follow-up tests, interventions, hospital stays, disease-specific medication, and the treatment of pathologies related to visual impairment and irreversible blindness.

Direct non-healthcare costs were those that occurred as a result of the adaptation or need of patients to mitigate the effects generated by visual diseases. These include informal care, transport, acquisition of devices for visual improvement, and housing adaptations.

The human capital method was used to calculate the costs associated with the loss of productivity, considering the annual cost validated by the Advisory Panel (Table 2). Only patients of working age (<65 years) were considered for this cost, thus only for glaucoma, DR, DME, and HM pathologies. No estimate was applied because the AMD population was outside this range.



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Glaucoma	1,339,669	1,364,194	1,389,215	1,414,590	1,440,368	1,466,553	1,493,102	1,520,034	1,547,402	1,575,177
DR	231,939	353,779	487,500	633,140	790,749	960,375	1,142,076	1,335,910	1,541,935	1,760,216
DME	431,934	508,791	592,881	684,228	782,863	937,530	1,103,954	1,282,190	1,472,295	1,674,335
AMD	738,493	779,312	806,799	822,797	855,696	872,436	904,142	921,632	939,531	957,878
HM	1,199,454	1,215,474	1,315,469	1,415,601	1,515,865	1,616,493	1,717,460	1,818,773	1,920,483	2,022,693
Total	3,941,489	4,221,549	4,591,864	4,970,357	5,385,540	5,853,387	6,360,734	6,878,539	7,421,645	7,990,299

Fig. 2 Variation of the populations with pathologies over the period 2021-2030. AMD: age-associated macular degeneration; DME: diabetic macular edema; HM: high myopia; DR: diabetic retinopathy

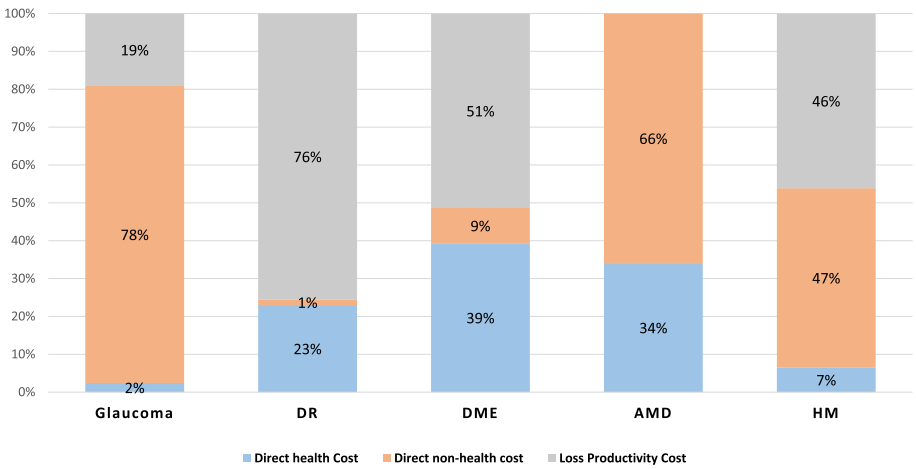


Fig. 3 Proportion of costs (direct health, direct non-health, and loss of productivity) to total cost for each pathology. AMD: age-related macular degeneration; DME: diabetic macular edema; DR: diabetic retinopathy; HM: high myopia

The cost estimates were extracted as reported in the publications and were updated to euros 2021 (€, 2021) using the annual variation of the Consumer Price Index (CPI). In cases in which the costs were from countries other than Spain, these were inflated using the CPI of each country published by the Organization for Economic Co-operation and Development (OECD) [35]. Secondly, to eliminate differences in the purchasing power between countries, a Purchasing Power Parity factor (PPP) was applied to convert the costs to Spanish euros.

To project the costs from 2022-2030, the annual variation of CPI in Spain over the last 10 years [36], was applied, assuming that this trend will continue for the next 10 years.

Results

Literature review

The PRISMA diagram obtained after conducting the two literature searches to achieve epidemiological and cost data is detailed in Additional file 2. The number of

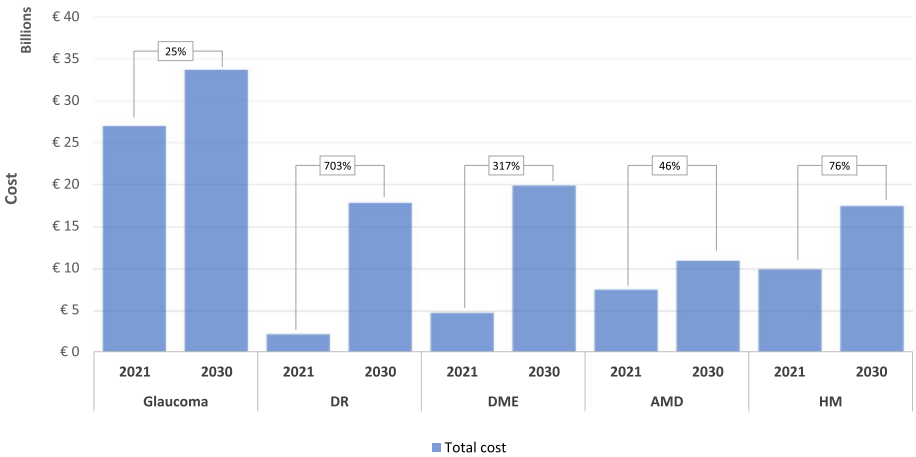


Fig. 4 Variation of the cost of pathologies in 2021 compared with 2030. AMD: age-associated macular degeneration; DME: diabetic macular edema; DR: diabetic retinopathy; HM: high myopia

Table 2 Parameters used to estimate the costs of patients

		Cost per year per patient, (€-PPP, 2021)[a]		
		Direct health cost	**Direct non-health cost**	**Loss of productivity cost**
Glaucoma	***POAG***	• Early: €427[b] [55, 56] • Intermediate: €489 [55] • Advance: €808[c] [55, 57]	€15,589 [14]	€6029 [14]
	PACG	€807[d] [58]		
Diabetic retinopathy (DR)	***Mild NPDR***	€376 [29]	€32 [59]	€6029 [14]
	Moderate NPDR	€6082 [29]	€259 [59]	
	Severe NPDR	€8923 [29]	€715 [59]	
	PDR	€13,888 [29]	€1027 [59]	
Diabetic macular edema (DME)		€4346 [29]	€1027 [59]	€7333 [14]
Age-related macular degeneration (AMD)	***Early***	€2673 [60]	€7011 [45]	€0[e]
	Intermediate	€4686 [60]		
	Wet	€3595 [60]		
	Dry			
High myopia (HM)	***HM***	€370 [34]	€4302 [34]	€4283 [34]
	HM + CNV	€2064 [34]	€4533 [34]	€4267 [34]

CNV choroidal neovascularization; *NPDR* non-proliferative diabetic retinopathy; *PACG* primary angle closure glaucoma; *PDR* proliferative diabetic retinopathy; *POAG* primary open angle glaucoma; *PPP* purchasing power parity factor

[a] The costs are form countries other than Spain, were applicated the purchasing power parity factor (PPP)

[b] Average cost obtained by Lorenz K, et al 2013 [55] and Kobelt G, et al 2010 [56]

[c] Average cost obtained by Lorenz K, et al 2013 [55] and Thygesen J, et al 2008 [57]

[d] Average cost obtained by the stages of early, moderate and advanced GACG to Traverso CE. Etal, 2005 [58]

[e] As the population was all over the age of 65, no costs were applied for any loss in productivity

potentially relevant publications found in PubMed was 1,666. In the first screening, 76 were eliminated because they were duplicated (n = 46) or because they were in a language other than Spanish or English (n = 30), leaving a total of 1,590 publications for screening based on the title and/or abstract. During this screening, 1,076 publications were eliminated because they were not European (n = 723), they did not include epidemiological and/or cost information (n = 343), or they included subjects who were under 18 years of age (n = 10). After reading the

full text of the articles, 496 publications were discarded because the published costs referred to specific treatments (n = 257) or therapies or outdated epidemiological data (n = 239), leaving a total of 18 publications.

In the identification of new studies by other methods, a total of 16 publications were obtained. After review, 3 were discarded because they referred to a population under 18 years of age (n = 1), did not include epidemiological or cost information (n = 1) or because the costs were for specific therapies (n = 1), leaving a total of 13 publications. Therefore, in total, 31 publications were considered for the analysis.

Cost analysis

Based on the selected epidemiological data, the number of patients with vision loss or blindness caused by glaucoma, DR, DME, AMD and HM, during the period 2021-2030 in Spain was estimated to be of 7.99 million, representing an increase of 103% in the number of patients in 2030 compared to 2021 (Fig. 2).

The pathologies with the highest population growth were those related to DM (DR and DME). In 2021, a population of 231,939 patients with DR was estimated, reaching 1,760,216 patients in 2030, which represents a growth of 659%. For DME, the number of patients in 2021 was estimated in 431,934 patients, increasing to 1,674,335 patients in 2030, an increase of 288%. However, in glaucoma, the population growth is lower; with an estimated 1.34 million patients in 2021 and 1.58 million patients in 2030, representing an increase of 18% over the 10 years analysed (Fig. 2).

The number of active patients of working age was estimated in 993,207 for glaucoma; 1,406,423 for DR; 1,295,869 for DME; and 1,629,825 for HM.

The total cumulative cost of all pathologies from 2021 to 2030 was 99.8 billion euros. Direct healthcare costs (€17.6 billion) represented the smallest cost item being the 18% of the total cost. Direct non-healthcare costs (€44.6 billion) accounted for the largest proportion (44%) of the total cost, and the cost generated by loss of productivity €38.2 billion represented the 38% of the total cost. Glaucoma and DME were the pathologies with the highest cumulative economic burden. Glaucoma generated a total cost of €33.6 billion and DME resulted in a total cumulative cost of €19.8 billion. The lowest cumulative cost obtained for the analysed period was for AMD (€10.9 billion). Overall, the average cost per patient per year was estimated to be €23,919 for glaucoma, €14,894 for DR, €13,659 for DME, €11,432 for AMD and €10,653 for HM (Table 3).

According to the type of cost (Fig. 3), direct healthcare costs accounted, with respect to the total cost, for a 2% (in glaucoma patients) to a 39% (in DME patients). The proportion that direct non-healthcare costs entailed ranged from 1% (DR patients) to 78% (glaucoma patients) and the costs generated by loss of productivity ranged from 0% (AMD patients) to 76% (DR patients).

When comparing the costs generated in the year 2021 with the estimated costs for the year 2030, the pathologies with the greatest increase would be those related to DM, such as DR and DME with cost increases of 703% and 317%, respectively. Glaucoma, AMD and HM would generate smaller increases in 2030: 25% in glaucoma, 46% in AMD and 76% in HM (Fig. 4).

Discussion

Vision loss and blindness in Europe are mainly associated with increasing life expectancy and an ageing population. Spain has a higher prevalence of vision loss (10.4%) compared to other European countries such as Portugal (7.4%), France (6.5%), Germany (6.9%) and England (6.4%) [37] and according to the latest results, the incidence of the main diseases causing vision loss and irreversible legal blindness is expected to increase in the coming years [4, 38]. However, there is no published

Table 3 Total cumulative cost of the pathologies for the period between 2021 and 2030

Year	Type of cost	Glaucoma	DR	DME	AMD	HM
2021	Direct health	€648,437,773	€829,673,619	€1,877,185,819	€2,555,400,732	€585,556,673
	Direct non-health	€20,884,099,220	€49,297,703	€443,596,373	€4,951,891,263	€5,179,381,545
	Loss of productivity[a]	€5,457,048,189	€1,344,994,951	€2,449,478,825	€0	€4,173,704,383
	Total cost	**€26,989,585,182**	**€2,223,966,273**	**€4,770,261,017**	**€7,507,291,995**	**€9,938,642,601**
	Cost per patient	***€22,251***	***€13,855***	***€12,706***	***€10,634***	***€9,909***
2030	Direct health	€818,505,909	€4,107,412,327	€7,822,407,143	€3,732,896,152	€1,141,122,221
	Direct non-health	€26,397,095,516	€266,791,065	€1,848,507,164	€7,219,360,354	€8,276,607,941
	Loss of productivity[a]	€6,437,145,948	€13,489,474,169	€10,215,355,390	€0	€8,064,294,515
	Total cost	**€33,652,747,373**	**€17,863,677,561**	**€19,886,269,697**	**€10,952,256,506**	**€17,482,024,677**
	Cost per patient	***€23,919***	***€14,894***	***€13,659***	***€11,432***	***€10,653***

[a] The loss of productivity was calculated only for the population aged 18 to 65 years

evidence on the economic impact of these diseases in Spain, especially from a societal and long-term perspective. To our knowledge, this is the first study of its kind to estimate the impact of these diseases over a 10-year period (2021-2030).

According to our results, the population with vision loss and blindness occurring as a consequence of glaucoma, DR, DME, AMD or HM would increase by 103% between 2021-2030, affecting to around 7.99 million people in Spain. This is higher than what it is expected in other countries with similar demographics [3, 39].

This growth is very significant in DM-related pathologies, despite the implementation of specific screening programmes. Our results estimate that populations with DR and DME will increase by 659% and 288%, respectively, by 2030. On the other hand, AMD will increase by up to 69%, in line with the results of other studies in European populations [38]. However, it is noteworthy that although several studies indicate that the prevalence of HM is increasing, mainly among younger age groups [34, 40], according to our results, it would be the pathology with the lowest growth in vision loss and blindness (18%) compared to the rest of the pathologies analysed, although it presents the largest population with vision problems.

The rise in diseases that cause irreversible vision loss and legal blindness has a significant economic impact, not just on healthcare systems but on society as a whole [15, 18, 41–43]. As our analysis reflects, the total cost of the main diseases that cause vision loss and irreversible legal blindness in Spain between the years 2021 and 2030 will reach €99.8 billion. Moreover, this cost would account for 8.3% of the country's GDP generated during the year 2020 [44], and is similar to that generated in other European countries [41].

These results were similar to other publications, such as that of Pezzullo L et al. [39] and Muscio A, et al. [14]. Our results indicate that direct costs represent approximately 12.6% in the year 2021 and 17.7% in the year 2030, being the lowest cost compared to direct healthcare costs and loss of productivity. In contrast, other countries indicate that direct healthcare costs account for the majority (87%) of the economic burden of visual diseases [42].

In addition, population ageing could be one of the factors related to the increase in costs [39]. Despite this, the increase in costs would not occur in the same way in all pathologies. In diseases with a diabetic origin, such as DR and DME, and with an early age of onset, the increase in the total cost would multiply in the year 2030 by 7.0 and 3.2, respectively, being more pronounced in DR. This increase could be due to the high direct healthcare cost due to comorbidities caused by metabolic diseases and the large increase in the diabetic population that will suffer from DR. It should be noted that glaucoma, being the pathology with the lowest cost increase in 2030, it is the pathology with the highest total cost. Direct non-healthcare costs associated with glaucoma generate the highest expenditures (78%). These results have also been observed in other similar studies [8]. Another pathology with a high non-healthcare cost is AMD, since it affects an older population with a high degree of dependence, which requires more informal cares [45].

The costs generated by the disability of the diseases described, understood as loss of productivity, would be very high, fundamentally in those pathologies that appear from earlier ages, such as DR and HM [13, 46].

According to our results, for diseases such as DR and DME, or even HM, the loss of productivity represents between 46% and 76% of the total cost generated, as a consequence of the loss of early productivity. In contrast, in age-related pathologies such as glaucoma or AMD, the costs generated as a consequence of loss of productivity are lower (19% in glaucoma and 0% in AMD). These results are comparable with other studies on disease burden. In Portuguese patients with vision loss, it has been estimated that the annual work productivity loss in these patients is 1.51 million euros per year (an average of 5,496 euros per patient) mainly generated by pathologies with a diabetic origin [13]. The average cost was lower in our study at €25,441 per patient by 2030.

In addition to the economic burden, the visual impairment produced by these pathologies could represent a great impact on the quality of life (QoL) of patients, since due to the loss of vision, their autonomy decreases, and they often suffer episodes of anxiety and depression [9, 10]. Some studies have shown that about 15% of patients with a concurrent ophthalmic condition were diagnosed with depression, being more acute in patients with dry eye syndrome, blindness or retinopathy. These patients had a higher economic burden, resulting in increased consumption of healthcare resources [47].

Therefore, it would be desirable that administrations and patient associations work in a coordinated manner to address these needs and generate regional plans for the prevention of irreversible legal blindness. In this way, it would be possible to reduce the cost generated [48], not only by the increased prevalence of these pathologies [49], but also by the need to manage their associated complications, which would improve the QoL of patients.

The main strength of this study is the evidence produced of the high economic burden associated with the loss of vision for the society. However, this project has a several limitations that should be considered. It has been necessary to assume certain premises validated by the panel of experts due to the lack of available published evidence. This lack of information highlights the need

for data to interpret the unmet needs of these patients. The epidemiological data projected in the analysis should be understood as an estimate of a future scenario. Likewise, the data for the analysis were extracted from different bibliographic sources as a result of the lack of data in our environment. However, these data have been selected from the sources with the best scientific evidence and have been validated by the panel of experts. Another limitation linked to our work is that we have not considered the possible efficacy that the treatments could be generating, which could imply a decrease in the appearance of vision loss and irreversible blindness in the populations analysed.

Investment in new diagnostic techniques and effective treatments could increase the direct healthcare costs associated with glaucoma, which could retard the progression to more advanced stages with even more vision loss, thereby lowering direct non-health costs [48]. It has been shown that in the early stages of glaucoma, a high percentage of patients are asymptomatic, so early detection is crucial to reduce the risk of irreversible blindness. Therefore, it is necessary to invest in therapeutic options that improve the treatment of this pathology and also in effective detection programs [50, 51].

The increase in the number of people with eye diseases and at risk of blindness calls for effective vision rehabilitation and blindness prevention programmes to prevent further vision loss. These programmes should emphasise the need to prevent the harmful effects of low vision in order to reduce its burden [8, 13].

These results highlight the need to establish strategies and prevention plans that allow earlier detection of the main diseases causing vision loss and irreversible blindness to reduce not only their incidence but also the number of people with visual impairment. In the case of preventable or treatable diseases, early recognition of these conditions and their timely treatment will reduce the number of visually impaired people. In addition, the use of Artificial Intelligence (AI)-based tools could help in early diagnosis [52, 53]. These policies as a whole can have a beneficial impact on the can have a beneficial impact on the overall burden on health and social systems.

Conclusions

Knowing the costs associated with vision loss and irreversible legal blindness is crucial to understand the socioeconomic impact associated with the pathologies analysed. The high cost of treating these diseases highlights the importance of generating citizen awareness campaigns that encourage attending ophthalmological examinations that help prevent these diseases or aid in their detection at an early stage.

Therefore, it is necessary to coordinate efforts between administrations, together with the support of patient associations, to meet the needs of these patients through the creation of effective regional plans for the prevention of blindness. To achieve this objective, it would be desirable to increase the investment of public health in this type of pathology, since in the medium-long term, it would have repercussions not only in direct benefits to the health of patients but also in economic relief for society.

Abbreviations

AMD	Age-related macular degeneration
CNV	Choroidal neovascularization
CPI	Consumer Price Index
DM	Diabetes mellitus
DM1	Diabetes mellitus, type 1
DM2	Diabetes mellitus, type 2
DME	Diabetic macular edema
DME1	Diabetic macular edema in patients with diabetes mellitus type 1
DME2	Diabetic macular edema in patients with diabetes mellitus type 2
DR	Diabetic retinopathy
HM	High myopia
INE	Spanish National Institute of Statistics
IOP	Intraocular pressure
NPDR	Non-proliferative diabetic retinopathy
OECD	Organisation for economic co-operation and development
ONCE	National Organization of the Spanish Blind
PACG	Primary angle closure glaucoma
PDR	Proliferative diabetic retinopathy
POAG	Primary open angle glaucoma
PPP	Purchasing power parity factor
QoL	Quality of life
SNS	Spanish National Health System
VA	Visual acuity

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

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Authors' contributions

AbbVie participated in the design and the development of this study and provided financial support for the study. AbbVie participated in the interpretation of data, review, and approval of the publication. No honoraria or payments were made for authorship.

LSO, AMC, ACG and MAC developed the model, reviewed the scientific literature, performed the analyses, and drafted the manuscript. LP, GGA, AGL, AF, IV, XA, JZ, DB, JS, IBR and JMRM validated the model structure and the inputs and provided information about the financial burden of the most important diseases associated with loss of vision and irreversible legal blindness in Spain. All the authors contributed to interpretation of the results and reviewed and approved the final version of the manuscript.

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Declarations

Ethics approval and consent to participate
Not applicable

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Competing interests
LP, AGL, AF, JZ and JMRM have received payments for the participation in advisory meetings for this project. No honoraria or payments were made for authorship or for any activity related to the publication development.
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JS was a paid employee of AbbVie during the development of the present work, and IBR is a paid employee of AbbVie and might have stock ownership or options. LSO, ACG and MAC are employees of Pharmacoeconomics & Outcomes Research Iberia (PORIB) a consultant company specialized in health technology assessment, which has received financial support from AbbVie to conduct the development of the present work. AMC was a paid employee of PORIB during the development of the present work.
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