Journal of Optometry 16 (2023) 182—188

Journal of Optometry

www.journalofoptometry.org

ORIGINAL ARTICLE

Prevalence of refractive error in Portugal — A systematic review and meta-analysis

Vera Lúcia Alves Carneiro, PhD *, José Manuel González-Méijome, PhD *

Clinical and Experimental Optometry Research Lab (CEORLab), Center of Physics - School of Sciences, University of Minho, Minho, Portugal

Received 30 March 2022; accepted 29 July 2022
Available online 29 August 2022

KEYWORDS
Refractive error;
Myopia;
Prevalence;
Portugal;
Eye care services

Abstract
Purpose: The aim of this study was to systematically review and meta-analyse epidemiological data of refractive error prevalence in Portugal.
Methods: A structured search strategy and systematic literature review was applied to multiple databases, such as MEDLINE/PubMed, Web of Science, Scopus, Google Scholar, official organizations and academic repositorium's, to identify all relevant epidemiological studies in Portugal until February 2021. The outcome measure was the prevalence of refractive error among the Portuguese population. The events and sample size were entered as raw data and the effect size parameters were computed by Comprehensive Meta-Analysis Software.
Results: A total of 9 studies were pooled for the meta-analysis. The fixed effects model points to an estimated effect size of 43% (95% CI: 41.9—44.1%). However, the statistics of heterogeneity (Q-value $p < 0.001$; I-squared =99.344) showed very high heterogeneity among studies and recommends using a random-effects model. The random effects model points to an estimated effect size of 31.9% (95% CI: 19.8—47.0%) prevalence of refractive error in the Portuguese population.
Conclusions: A prevalence of refractive error in Portugal of 31.9% (95% CI: 20.0—47.0%) can be considered as a conservative approach to the real burden of this condition. However, it translates into at least 2 to 4.5 million Portuguese individuals with a refractive error. The high heterogeneity between studies, the wide estimate and the random effects involved demonstrate the need for more studies and consistent sources to obtain narrower estimates.

Introduction

A substantial increase in the number of cases of vision impairment and blindness is anticipated due to the shift in the disease burden towards non-communicable diseases and disabilities, as refractive error, resulting from demographic and

* Corresponding author.
E-mail addresses: vera0carneiro@gmail.com (V.L. Alves Carneiro), jgmeijome@fisica.uminho.pt (J.M. González-Méijome).

https://doi.org/10.1016/j.optom.2022.07.003
1888-4296/

evolutionary changes in the population.[1] Refractive error is considered a public health challenge, being the most common eye condition and affecting all age groups. The World Health Organization 2019 World Report on Vision indicate that refractive error is the leading cause of vision impairment contributing to 123.7 million cases of moderate to severe distance vision impairment or blindness.[2] Data on the prevalence and progression of refractive error in Portugal are scarce and heterogeneous, and in this way, the contribution of this condition to the total national burden of vision impairment or blindness is unknown. To address this gap on the literature assumes bigger importance on a public health perspective. Data on the cause-specific prevalence of vision impairment and blindness is essential to inform decision-makers and the society in the process of planning eye care services and optimally allocate resources.

Retrospective analysis of the Portuguese National Program for Eye Health 2012−2016 and extension to 2020

The Portuguese National Program for Eye Health 2012−2016 - revision and extension to 2020 [3] had the following targets: to reduce the proportion of undiagnosed eye health problems in children, young people and adult population; to reduce the predictable incidence and prevalence of blindness and vision impairment associated with pathologies that can be treated appropriately; and to reduce the proportion of eye care problems that cause loss of functionality and independence in people aged ≥ 55 years. To achieve these targets, two intervention strategies were defined: screening and early diagnosis. According to the established by the WHO Universal Eye Health - Global Action Plan 2014−2019,[4] the Portuguese National Program for Eye Health 2012−2016 - revision and extension to 2020 intervention strategies implementation should have been replicated and adapted regionally, considering the local specificities and existing resources in order to improve universal access to eye care.

The strategies definition, made in a vast way, without specific actions and interventions duly substantiated, without evidence-based or a cost-benefit analysis for each intervention, without a definition of a temporal goal and disregarding integrated-people centred care,[5] allows to retrospectively analyse that it did not met the established targets.

Data from 2017, on the coverage and response times of eye care services by the Health System Central Administration (ACSS, IP), shows that the targets are far from being achieved, with 181 824 form the 313 941 eye care patients request not being attended and 111 831 being attended out of the 150 days defined as maximum response time that must be ensured (average waiting time of 171 days, with a maximum of 603 and minimum of 38 days). Also, there was an evident deterioration in the median wating time for ophthalmological surgery, having increased to 2,6 in 2019, with 57 170 individuals waiting for surgery.[6,7]

Access to optical devices correction is also compromised since for the access to reimbursement it is necessary to have a prescription issued by the National Health Service (NHS) with the access barriers and extensive waiting lists, making universal eye care coverage unfeasible and not allowing the achievement of the Portuguese National Program for Eye Health defined targets.[6]

This information allows us to conclude that the Portuguese National Program for Eye Health 2012−2016 - revision and extension to 2020 implementation does not have contribute to an increase in universal eye care coverage, nor to the reduction of the leading causes of avoidable VI. On the contrary, a significant deterioration in the care provided is observed, with longer waiting times and difficulties in access to care and optical devices correction.

The planning and definition of an intervention strategy must pass through a correct epidemiological diagnosis of the conditions to be intervened and direct the provision of care to the population's needs, safeguarding the predictable demographic developments.

Uncorrected refractive error as leading cause of vision impairment in Portugal

Refractive error are one of the leading causes of vision impairment worldwide,[2] despite that, data on the refractive error prevalence and progression in Portugal are scarce and heterogeneous, and in this way eye care services planning have failed consecutively over the years to address this problem.[6,8,9]

Still far from achieving the feasible global target for effective coverage of refractive error,[5] the number of refractive error cases seems to be increasing, representing significant economic implications, not only immediate but in terms of potential lost productivity, in both low and high-income countries.[2,10,11] The scenario in Portugal, despite the lack of data, is estimated to follow the same worldwide trend, which makes refractive error a priority issue in current eye care and public health research. Despite the limitations in the comparison of refractive error prevalence between different studies, because of different definitions, measurement techniques or sampled populations, collecting and analysing the published data can be a starting point to draw a more realistic scenario of uncorrected refractive error in Portugal as a starting point to advocate for the provision of initiatives to reduce the burden of this condition within the population.

This study aimed to systematically review and meta-analyse epidemiological data of refractive error prevalence in Portugal, using existing published evidence.

Methods

Literature search strategy and sources of epidemiological data

A systematic search and literature review was conducted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) procedures.[12]

Multiple national and international electronic scientific databases, such as MEDLINE/PubMed, Web of Science, Scopus, Google Scholar, official organizations databases and academic repositorium's were systematically searched to retrieve all potentially relevant publications of epidemiological studies about prevalence and incidence of refractive error in Portugal. A comprehensive search strategy, tried to be free from error, was conducted combining terms related to epidemiology (prevalence, incidence, epidemiology, frequency), terms related to the outcome of interest (refractive error, myopia, hyperopia, astigmatism) and affiliation (Portugal) combined by Boolean operators (OR, AND) or not. No time interval for the studies conduction has been defined.

For every publication or paper found, the reference list was reviewed searching for additional studies or data in an attempt to retrieve all the relevant information.

Inclusion and exclusion criteria and data extraction

Publications were selected based on the following inclusion criteria: exploring the prevalence, incidence, or other epidemiological data of the different refractive error (myopia, hyperopia, and astigmatism); assured peer review in poster, academic thesis/dissertation, and scientific publication formats; from all the geographical regions of Portugal and in Portuguese or English language. Exclusion criteria were the same data used in separated studies.

Each paper was reviewed, and information/data was extracted based on the following characteristics: author's name, title, study year, publication format (poster, academic thesis or dissertation or scientific publication), study type, sample size, population age range, sex ratio, refractive error assessment method, refractive error definition, refractive error prevalence and, if applicable myopia, hyperopia, and astigmatism prevalence.

Statistical analysis

A meta-analysis was conducted using the Comprehensive Meta-Analysis Software (CMA, Englewood, NJ, USA). The outcome measure was the prevalence of refractive error among the Portuguese population, including myopia, hyperopia, and astigmatism. The events and sample size were entered as raw data and the effect size parameters (event rate, logit event rate, standard error) were computed by CMA.

Results

A total of 11 studies were found and 2 were excluded because they were different representations of a same study already use, a poster and a thesis already included as a

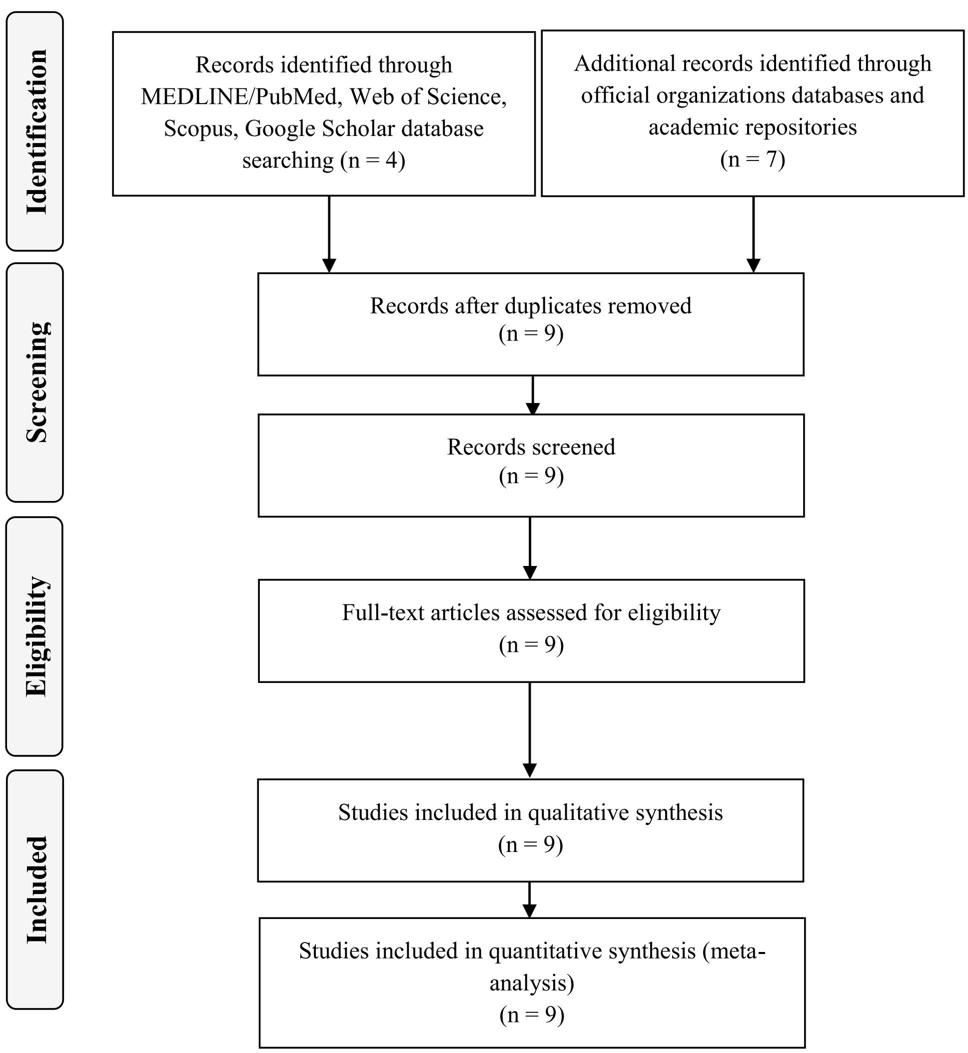

Fig. 1 Flow chart of the process of study selection - adapted from Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7):e1000097.[12]

Table 1 Studies reporting on the prevalence of refractive error in the Portuguese population (SE: spherical equivalent and D: diopters).

Author	Year	Study type	Age (Mean ± SD)	Sex ratio	Sample Size (N)	Refractive error definition criteria	Refractive error prevalence
Queirós, et al.[13]	1999–2004	Clinical records retrospective study	40.08 ± 18.75	F 2351(54.8%); M 1937(45.2%)	4288	Myopia SE ≤ −0.50D, Emmetropia −0.50 < SE < +0.50D and Hyperopia SE ≥ 0.50D	54.9%
Jorge, et al.[14]	2002–2005	School-based 3-year longitudinal study	20.6 ± 2.3	F 54 (71.2%);M 34 (28.8%)	118	Myopia SE ≤ −0.50D, Emmetropia −0.50 < SE < +0.50D and Hyperopia SE ≥ 0.50D	66.9%
Lança, et al.[15]	2012	School-based cross-sectional study	7.69 ± 1.19	F 362 (53.9%); M 310 (46.1%)	672	Hyperopia ≥ +3.75D; Astigmatism ≥ 1.75D and Myopia ≤ −0.75D	30.1%
Carvalho, et al.[16]	2012	Population survey	–	F 430 (66%) M 224 (34%)	654	Myopia SE ≤−1,00D; High Myopia SE ≤−5,00D; Hyperopia SE ≥ +3,00D	40.5%
Barros, et al.[17]	2013	Population survey	–	F 429 (65.8%) M 223 (34.2%)	652	Myopia SE ≤−1,00D; High Myopia SE ≤−5,00D; Hyperopia SE ≥ +3,00D	37.0%
González-Méijome, et al.[18]	2013–2015	School-based longitudinal pilot study	9 ± 2	F 52 (48%) M 56 (52%)	108	Myopia SE ≤ −0.50D and Hyperopia SE ≥ 0.50D	38.0%
Queirós, et al.[19]	2017	Scholl-based population survey	14.84 ± 4.72	F 401 (57.4%) M 298 (42.6%)	699	Myopia SE ≤ −0.50D, Emmetropia −0.50 < SE < +0.50D and Hyperopia SE ≥ 0.50D	44.2%
Jorge, et al.[20]	2017	School-based cross-sectional study	9.8 ± 2.9	F 733 (52.0%) M 676 (48.0%)	1409	Myopia SE ≤−1.00D, Hyperopia SE ≥ +3,00D	11.5%
Carneiro, et al.[21]	2016	Cross-sectional paediatric hospital-based study	2.2 (no SD)	F 635 (45.5%); M 760 (54.5%)	1395	Cut-off for referral: ≥ 2D myopia, ≥ 1.5D hyperopia	3.9%

scientific publication (Fig. 1). Data from the remaining 9 studies were pooled for the meta-analysis

The characterization of the 9 studies included in the qualitative and quantitative synthesis are summarized in Table 1. The studies years range from the 1999 to 2017. The immediate qualitative analysis shows a high heterogeneity between the studies regarding sample sizes and age range.

Data was entered in the CMA software as sample and number of events and the Event Rate, Lower and Upper limits, Z-Value, p-Value were calculated as shown in Table 2 for each study included in the meta-analysis. The outcomes of the meta-analysis are presented in Table 3 including the statistics for the fixed and random models.

The fixed and random model estimates point to an effect size in the range closer to 40% prevalence of refractive error in the Portuguese population. While the random effects model points to an estimated effect size of 31.9% within a confidence interval of 19.8% to 47%, the fixed effects model narrows down the estimate to 43% within a confidence interval of 41.9 to 44.1%. Despite the statistics of heterogeneity recommend when using a random-effects models for subsequent analysis, in the Table 3 below, the results of both models are presented to ensure that all statistics produced are displayed. Subsequent graphical presentation, including forest plot in Fig. 2 will only represent the random-effects model.[22]

On the test for heterogeneity, Q-value was statistically significant demonstrating that there was significant heterogeneity among studies ($p < 0.001$). Along with the value of I-squared parameter, we can conclude that the heterogeneity was very high. Considering the I-square heterogeneity parameter of 99.344 we can conclude that over 99% of the variance between studies can be attributed to real differences in the effect size and less than 1% of the variance can be expected from random error. According to recommendations from Higgins et al.,[23] considering the high value of the I-squared parameter, a random effects model needs to be applied and this is graphically shown in Fig. 2 below.

Forest plots displayed in Fig. 2 show graphically the results previously presented in tables. It is apparent from both plots the high between-studies variance (variable effect sizes from 0 to over 0.5). The variance between studies was also high as shown in Table 3 by the Tau-squared parameter being high (Tau^2=0.942). Some studies show a low within-study variance (narrow intervals) while others show a larger variance (larger intervals). As previously observed in the tables, the average effect size confidence interval was larger for the random effects than the fixed effects model.

Discussion

Refractive error is the leading cause of vision impairment, and most important, preventable vision impairment. Many studies have evaluated their epidemiology and reported their prevalence. The prevalence and distribution of refractive error are not equal in different countries, and the ongoing need of refractive error patients for services and devices gives greater importance to the burden of this eye condition within a country population.[1]

The most important limitation of this work is the lack of studies and the high heterogeneity between the existent studies that demonstrate the random effects involved. As a result, the estimate for the prevalence of refractive error (95% CI: 20 to 47%) is too broad. More data and more consistent sources are needed to obtain more restricted estimates. Despite the known variations in groupings according to age or sex,[2] this work didn't allow to disaggregate the prevalence of refractive error at that level. Differences in the type of study, target population and definition criteria of refractive error are the main differences between the existent studies. That shows the need not only of more studies but with a standardized methodology to obtain more restricted estimates.

The meta-analysed prevalence of refractive error in Portugal of 31.9% (95% CI: 19.8—47.0%) can be considered as a conservative approach to the real burden of this condition within the Portuguese population. This value indicates that at least 2 to 4 million Portuguese individuals suffer from a refractive error. Previous national reports estimates that about 20% of children and 50% of the adult population have significant refractive error.[3]

Comparing with a more comprehensive European analysis, a study from an eye care epidemiological consortium estimates that over a half of European adults are affected by a refractive error.[24]

Table 2 Data entered in the CMA software (Age, Sample and Events) and computed by the software (Event Rate, Lower and Upper limits, Z-Value, p-Value) in the shadowed cells.

Author	Age entered	Refractive error events (*n*)	Event rate	Lower limit	Upper limit	Z-value	*p*-value
Queirós, et al.[13]	40.08	2356	0.549	0.535	0.564	6.464	<0.001
Jorge, et al.[14]	20.6	79	0.669	0.580	0.748	3.607	<0.001
Lança, et al.[15]	7.69	202	0.301	0.267	0.336	−10.037	<0.001
Carvalho, et al.[16]	—	265	0.405	0.368	0.443	−4.819	<0.001
Barros, et al.[17]	—	241	0.370	0.333	0.407	−6.579	<0.001
González-Méijome, et al.[18]	9	41	0.380	0.293	0.474	−2.477	0.013
Queirós, António et al.[19]	14.84	309	0.442	0.406	0.479	−3.057	0.002
Jorge, et al.[20]	9.8	162	0.115	0.099	0.133	−24.438	<0.001
Carneiro, et al.[21]	Mean 2.2	55	0.039	0.030	0.051	−23.209	<0.001

Table 3 Meta-analysis results for fixed and random model estimates of effect size and 95% confident interval, Z-value.

Model	Effect Size and 95% confidence interval			Dispersion Test (null hypothesis)		Heterogeneity		Variance between studies			
	Point Estimate	Lower Limit	Upper Limit	Z-value	p-value	Q-value (p-value)	I-squared (I^2)	Tau^2	Standard Error	Variance	Tau
Fixed	0.430	0.419	0.441	−12.416	$p < 0.001$	1219.244	99.344	0.942	0.665	0.442	0.970
Random	0.319	0.198	0.470	−2.330	$p = 0.020$						

There is no exact data on vision impairment prevalence in Portugal, however, studies have extrapolated or inferred this numbers using data from countries in the same global burden of disease region (Western Europe). According to Bourne *el al*, 2014, the estimate for Portugal shows that, for the population with 50 years old or more, there are 263 748 Portuguese individuals (6.2%) with moderate or severe visual impairment and about 42 540 (1.0%) with blindness. The uncertainty interval, however, indicates that these estimates are a very gross picture for Portugal and further prevalence studies are necessary.[25] Data from the 2001 Portuguese censuses, with the limitations inherent to this data collection source, reveals 163 569 disable individuals from visual impairment. Visual impairment thus represents the biggest contributor to the total burden of disability in Portugal, with the same proportion between men and women.[26] More recent data, from the 2011 Health and Disability Report in Portugal from the National Statistics Institute, shows that for Portuguese people with at least one disability, which represents 17,4% of people between 15 and 64 years old, visual impairment, even with optical correction, represents 17,2%, most affecting women; and for people aged 65 years old or more with at least one disability, 50% had visual impairment, even with optical correction.[27]

Knowing that numerous studies, at regional or global level, conclude that refractive error are a leading cause of vision impairment contributing for approximately 40% of the cases,[2,28–30] and considering the estimate values of vision impairment prevalence mentioned for Portugal, we can consider that a refractive error prevalence of 31.9% (95% CI: 20.0–45.0%) is an estimated value very close to the real or even lower than the real verified for the Portuguese population.

Conclusion

The high heterogeneity between studies, the wide estimate for refractive error prevalence (95% CI: 19.8 to 47%) and the random effects involved lead to that the main conclusion to be drawn from this study being the demonstration of the need for more studies (population base surveys) and more consistent sources to obtain narrower estimates on the prevalence and incidence of refractive error in Portugal.

However, and even assuming a conservative posture, a prevalence between 20.0 – 47.0% translates into at least 2 to nearly 5 million Portuguese individuals suffering from a refractive error and places the refractive error as one of the conditions with more burden on the health system and the national population, demonstrating the need to be addressed in a public health context.

The results of this study sustain the need to create refractive services, to adopt the integrated people-centred eye care strategy[5] to address this condition, contributing to the reduction/elimination of avoidable vision impairment due to refractive error that contribute to greater exposure to morbidities, higher mortality rates, lower quality of life and greater risk of exposure to poverty.[2]

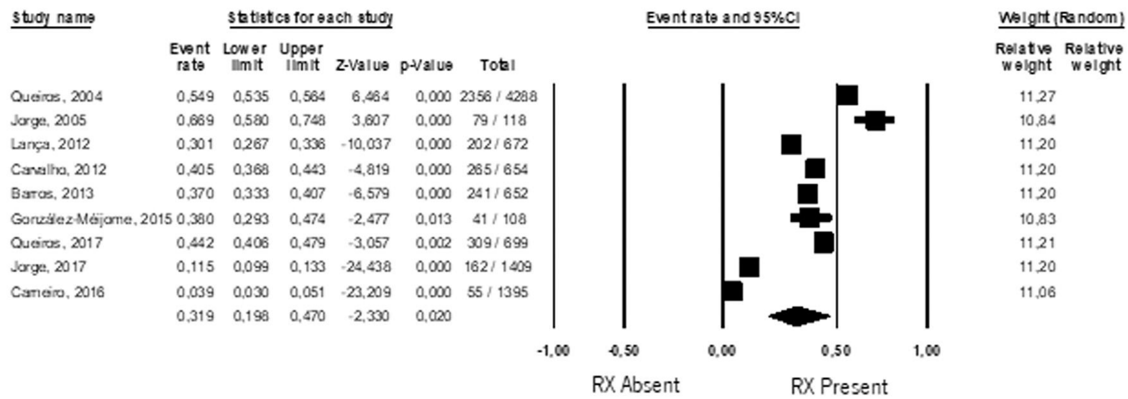

Fig. 2 Forest plot for the random effects model including the effect size (middle point of each study) and within-study variance (horizontal amplitude) for each study and mean effect size (bottom diamond).

Declarations of interest

None.

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

References

1. Bourne RRA, Steinmetz JD, Saylan M, et al. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: the Right to Sight: an analysis for the Global Burden of Disease Study. *Lancet Glob Heal*. 2021;9(2):e144–e160.
2. World Health Organization. *World Report on Vision*. 2019.
3. Directorate-General of Health. *National Program for Vision Health - Review and Extension 2020*. 2016.
4. World Health Organization. *Universal Eye Health: A Global Action Plan 2014–2019*. 2014.
5. World Health Organization. *Integrated People-Centred Eye Care, Including Preventable Vision Impairment and Blindness*. 2020.
6. Lourenço A, Pita Barros P. *Estudo Para a Universalização de Cuidados de Saúde Da Visão Em Portugal*. 2019.
7. Serviço Nacional de Saúde. *Relatório Anual Acesso a Cuidados de Saúde Nos Estabelecimentos Do SNS e Entidades Convencionadas*. 2019.
8. Carneiro VLA, Andrade H, Matias L, de Sousa RARC. Post-COVID-19 and the Portuguese national eye care system challenge. *J Optom*. 2020;13(4):257–261.
9. Direção Geral de Saúde. *Estratégia Nacional para a Saúde da Visão*. 20182018:1–126. Published online.
10. Naidoo KS, Leasher J, Bourne RR, et al. Global Vision Impairment and Blindness Due to Uncorrected Refractive Error, 1990-2010. *Optom Vis Sci*. 2016;93(3):227–234.
11. Rein DB, Zhang P, Wirth KE, et al. The economic burden of major adult visual disorders in the United States. *Arch Ophthalmol*. 2006;124(12):1754–1760.
12. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA Statement. *PLoS Med*. 2009;6(7): e1000097.
13. Queirós A, Ferrer-Blasco T, Jorge J, et al. Prevalence of refractive conditions in the general population attending eye care clinics in the north of Portugal. *Atti della Fond GiorgioRonchi*. 2009:(64):101–111.
14. Jorge J, Almeida JB, Parafita MA. Refractive, biometric and topographic changes among Portuguese university science students: a 3-year longitudinal study. *Ophthalmic Physiol Opt*. 2007;27(3):287–294.
15. Lança C, Serra H, Prista J. Strabismus, visual acuity, and uncorrected refractive error in portuguese children aged 6 to 11 years. *Strabismus*. 2014;22(3):115–119.
16. Carvalho ASB de. *Prevalência dos Erros Refrativos em Portugal Usando Informação Proveniente da Venda de Receituário*. 2013. Published online.
17. Barros DB. *Estudo Epidemiológico das Ametropias em Portugal II*. 2013. Published online.
18. González-Méijome J, Faria-Correia F, Marques C, et al. Two-year change in refractive error prevalence in a school population from 6 to 13 years of age in portugal: longitudinal pilot study. *In:* Poster. 2017.
19. Queirós A, Faria-Correia F, Marques C, et al. Refractive error and axial length at different school levels from 6 to 23 years of age in a Portuguese population. *In:* Poster. 2017.
20. Jorge J. Myopia prevalence in Portuguese Schoolchildren - Poster P011. *Ophthalmic Physiol Opt*. 2018;38:215–216.
21. Carneiro IS, Dias D, Casal I, et al. Preverbal visual photo screening Project implementation in Portugal. *Rev Bras Oftalmol*. 2018;77(3):133–136.
22. Borenstein M., Hedges L. Meta-Analysis Fixed effect vs. random effects. Published online 2007. Accessed December 1, 2021. www.Meta-Analysis.com.
23. Higgins JPT, Thompson SG, Spiegelhalter DJ. A re-evaluation of random-effects meta-analysis. *J R Stat Soc Ser A Stat Soc*. 2009;172(1):137.
24. Williams KM, Verhoeven VJM, Cumberland P, et al. Prevalence of refractive error in Europe: the European Eye Epidemiology (E3) Consortium. *Eur J Epidemiol*. 2015;30(4):305–315.
25. Bourne RRA, Jonas JB, Flaxman SR, et al. Prevalence and causes of vision loss in high-income countries and in Eastern and Central Europe: 1990-2010. *Br J Ophthalmol*. 2014;98(5):629–638.
26. PORDATA SPI|. *População Residente com Deficiência Segundo os Censos: Total e por Tipo de Deficiência (2001)*. 2021. Published 2001. Accessed March 24; https://www.pordata.pt/Portugal/População+residente+com+deficiência+segundo+os+Censos+total+e+por+tipo+de+deficiência+(2001)-1239-9822.
27. Statistics Portugal IP. *Relatório Saúde e Incapacidades Em Portugal 2011*. 2011.
28. Muñoz B, West SK, Rodriguez J, et al. Blindness, visual impairment and the problem of uncorrected refractive error in a Mexican-American population: proyecto VER | IOVS | ARVO Journals. *Investig Ophthalmol Vis Sci*. 2002;43(3): 608–614.
29. Resnikoff S. Global data on visual impairment in the year 2002. *Bull World Health Organ*. 2004;82(11):844–851.
30. Ntim-amponsah C. Contribution of refractive errors to visual impairment in patients at korle-bu teaching hospital. *Ghana Med J*. 2010;41(2):68.