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The Decreasing Prevalence of Nonrefractive Visual Impairment in Older Europeans

A Meta-analysis of Published and Unpublished Data

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Topic: To estimate the prevalence of nonrefractive visual impairment and blindness in European persons 55 years of age and older.

Clinical Relevance: Few visual impairment and blindness prevalence estimates are available for the European population. In addition, many of the data collected in European population-based studies currently are unpublished and have not been included in previous estimates.

Methods: Fourteen European population-based studies participating in the European Eye Epidemiology Consortium (n = 70 723) were included. Each study provided nonrefractive visual impairment and blindness prevalence estimates stratified by age (10-year strata) and gender. Nonrefractive visual impairment and blindness were defined as best-corrected visual acuity worse than 20/60 and 20/400 in the better eye, respectively. Using random effects meta-analysis, prevalence rates were estimated according to age, gender, geographical area, and period (1991–2006 and 2007–2012). Because no data were available for Central and Eastern Europe, population projections for numbers of affected people were estimated using Eurostat population estimates for European high-income countries in 2000 and 2010.

Results: The age-standardized prevalence of nonrefractive visual impairment in people 55 years of age or older decreased from 2.22% (95% confidence interval [CI], 1.34–3.10) from 1991 through 2006 to 0.92% (95% CI, 0.42–1.42) from 2007 through 2012. It strongly increased with age in both periods (up to 15.69% and 4.39% in participants 85 years of age or older from 1991 through 2006 and from 2007 through 2012, respectively). Age-standardized prevalence of visual impairment tended to be higher in women than men from 1991 through 2006 (2.67% vs. 1.88%), but not from 2007 through 2012 (0.87% vs. 0.88%). No differences were observed between northern, western, and southern regions of Europe. The projected numbers of affected older inhabitants in European high-income countries decreased from 2.5 million affected individuals in 2000 to 1.2 million in 2010. Of those, 584 000 were blind in 2000, in comparison with 170 000 who were blind in 2010.

Conclusions: Despite the increase in the European older population, our study indicated that the number of visually impaired people has decreased in European high-income countries in the last 20 years. This may be the result of major improvements in eye care and prevention, the decreasing prevalence of eye diseases, or both. *Ophthalmology 2018;125:1149-1159 © 2018 by the American Academy of Ophthalmology*

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Visual impairment and blindness have profound human and socioeconomic consequences in all societies. People with vision loss experience a reduced quality of life,[1,2] greater difficulty with daily living and social dependence,[3,4] higher rates of depression,[5,6] and an increased risk of falls and related hip fractures.[7,8] Worldwide, vision loss is a leading cause of disability.[9] The costs of lost productivity, rehabilitation, and education of the blind constitute a considerable economic burden for the individuals, their family, and society. Vision loss also incurs both direct health care costs and indirect costs of lost productivity, welfare, and informal care.[10] The global annual cost of

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visual impairment was estimated in United States dollars to be $3000 billion ($563 billion for Europe).[11] Since 1999, prevention of visual impairment and blindness has been a priority of the World Health Organization (WHO), through its joint program with the International Agency for the Prevention of Blindness, known as VISION2020: The Right to Sight.[12] In 2013, the World Health Assembly adopted a new global action plan for the prevention of avoidable blindness and visual impairment for the period 2014 through 2019.[13]

A common cause of visual impairment is refractive error (such as myopia, hyperopia, astigmatism, or presbyopia), which can be corrected using optical correction (spectacles or contact lenses).[14] Thus, visual impairment resulting from refractive error often is termed *correctable visual impairment*, whereas visual impairment from other causes is often termed *uncorrectable visual impairment* or *nonrefractive visual impairment*. Worldwide, major causes of nonrefractive visual impairment currently are age-related eye diseases (cataract, age-related macular degeneration [AMD], glaucoma, and diabetic retinopathy).[15] For this reason, visual impairment is much more frequent in older individuals. Globally, 65% of visually impaired persons and 82% of the blind persons are 50 years of age or older.[15]

Although estimates of the prevalence of visual impairment and blindness are published regularly for the United States,[16–19] such estimates are reported less often for the European population. Although many epidemiologic studies have been conducted in Europe,[2,20–24] there have been few attempts to harmonize these studies to provide estimations of the prevalence of visual impairment throughout the continent. In 2011, the EUREYE Study suggested that the prevalence of visual impairment and blindness may be higher in Southern Europe than in Northern Europe (with the exception of Tallinn, Estonia, demonstrating prevalence rates as high as in Southern Europe) and that European women may be more affected than European men.[2] However, this study was performed in 6 cities from 6 European countries (Bergen, Norway; Tallinn, Estonia; Belfast, United Kingdom; Paris-Créteil, France; Verona, Italy; and Thessaloniki, Greece), with a total of 4166 participants, and may not be representative of the entire European continent. In 2014, prevalence rates for the European continent were estimated in a systematic review and meta-analysis performed by the expert group convened for the Global Burden of Diseases, Injuries and Risk Factors (GBD).[25,26] This meta-analysis suggests that the prevalence of visual impairment and blindness has decreased in recent decades on all continents, and in particular in Europe. It also shows higher prevalence rates of visual impairment in Central and Eastern Europe compared with Western Europe, and somewhat higher prevalence of visual impairment in women compared with men. However, because this meta-analysis relied on published data, the definitions (thresholds, type of optical correction) and reporting (in particular age groups) of visual impairment differed widely among the included studies, although these differences in part were addressed by the authors using complex statistical modeling. In addition, many European population-based studies have collected data on visual impairment without publishing prevalence estimates, and thus could not be included in this meta-analysis.

The European Eye Epidemiology (E^3) consortium is a collaborative initiative among 41 epidemiologic studies across Europe to share and meta-analyze epidemiologic data on ocular health.[27] The aim of the present study was to provide more precise estimates of the prevalence of nonrefractive visual impairment in older Europeans and to assess potential temporal trends and geographical variations.

Methods

Studies and Participants

To date, E^3 comprises data from 41 studies with a range of ophthalmic data on approximately 170 000 individuals from population-based and other studies (case control, cases only, randomized trials).[27] The present study was based on the 14 E^3 population-based studies that collected best-corrected visual acuity (BCVA) data (n = 70 723 participants). Studies in the E^3 consortium were eligible for inclusion in this analysis if they were population based and had available data on BCVA, together with gender, age at measurement, and year of measurement.

As described in Table 1, participants included in this meta-analysis mainly were of middle to late age. Because only a few studies included participants younger than 55 years, we estimated prevalence of visual impairment and blindness only in participants older than this age. Visual acuity measurements were performed between 1991 and 2012. Designs and methods of included studies are described in the Supplemental Material (available at www.aaojournal.org). All studies adhered to the tenets of the Declaration of Helsinki, and relevant local ethical committee approvals with specific study consent were obtained. Written consent was obtained for all participants.

Demographic and Outcome Variables

All included studies measured distance visual acuity (mostly using Snellen or Early Treatment of Diabetic Retinopathy Study charts) with optimal refractive correction. Definitions of visual impairment and blindness vary in the literature. According to the WHO, moderate to severe visual impairment is defined as visual acuity in the better eye of worse than 6/18, but 3/60 or better, whereas blindness is defined as a visual acuity worse than 3/60. By contrast, in the United States, the threshold for visual impairment is 20/40. To be as comparable as possible with previous studies and to use all available data in the participating studies, we used the following definitions of visual impairment and blindness:

1. Nonrefractive visual impairment (WHO standard): BCVA worse than 6/18 (or 20/60) in better eye.
2. Nonrefractive visual impairment (United States standard): BCVA worse than 6/12 (or 20/40) in better eye.
3. Nonrefractive blindness: BCVA worse than 3/60 (or 20/400) in better eye.

Differences in visual impairment by age (in 10-year age bands from 55–64 years to ≥85 years), gender, period (1991–2006 and 2007–2012, using the median of study periods), and geographical European region were examined. Countries were divided into 3 regions (Northern, Western, and Southern Europe) according to the United Nations Geoscheme.[28] No data were available from Eastern Europe.

Table 1. European Population-Based Studies with Visual Acuity Data Participating in the European Eye Epidemiology Consortium

Study Name	Country	Period of Visual Acuity Data Collection	Age Range (yrs)	No. of Participants with available Best-Corrected Visual Acuity
Rotterdam I	Netherlands	1991–1993	55+	6919
MRC trial	United Kingdom	1995–1998	75+	14 593
POLA	France	1995–1998	60+	2569
Rotterdam II	Netherlands	2000–2002	55+	2662
Eureye	Norway, Estonia, United Kingdom, France, Italy, Greece	2001–2002	65+	4166
Thessaloniki	Greece	2000–2005	60+	2259
Pamdi	Italy	2005–2006	60+	885
EPIC-Norfolk	United Kingdom	2004–2011	45+	8563
Alienor	France	2006–2008	73+	962
Rotterdam III	Netherlands	2006–2009	45+	3485
Tromsø 6th	Norway	2007–2008	40+	6438
Gutenberg Health Study	Germany	2007–2012	35–74	13 215
Coimbra Eye Study	Portugal	2009–2011	55+	2981
Montrachet	France	2009–2012	75+	1026
Total				70 723

EPIC = European Prospective Investigation into Cancer; MRC = Medical Research Council; POLA = Pathologies Oculaires Liées à l'Age.

Statistical Analysis

For each visual end point, the investigators from each study provided the number of individuals stratified by gender and age group (55–64 years, 65–74 years, 75–84 years, and 85 years or older). Random effects meta-analyses were performed to estimate prevalence rates. Random effects modeling was chosen over a fixed-effects model to take into account heterogeneity in study design characteristics. Subgroups with fewer than 50 observations were excluded from the analyses.

We first evaluated the variation in prevalence of nonrefractive visual impairment and blindness with gender, period, and geographical area. Because nonrefractive visual impairment and blindness vary strongly with age and the age range was quite different among studies, we estimated age-standardized prevalence rates for all those 55 years of age or older using the following steps. First, for each stratum of gender, period, and geographical area, prevalence rates were estimated using random effects meta-analyses in each age group (55–64 years, 65–74 years, 75–84 years, and 85 years or older). Second, an age standardization to the age-specific European population was performed using the European Standard Population 2010.[29] This enabled prevalence estimates that are representative for the European population, with appropriate weighting to the age demographic distribution of Europe. Subsequently, random-effects meta-analyses were performed with stratification by age, gender, and period.

Finally, to estimate the numbers of people affected by visual impairment and blindness, we applied the age- and period-specific prevalence rates to the population of European high-income countries, as defined by the GBD (Andorra, Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom).[25] Population estimates were obtained from Eurostat. To obtain the estimates of numbers of people affected by visual impairment and blindness for the year 2000, we applied prevalence estimates of visual impairment and blindness for the 1991 through 2006 period to the Eurostat estimates of population for year 2000. Similarly, for the year 2010, we applied visual impairment and blindness prevalence estimates for the 2007 through 2012 period to the Eurostat population estimates for the year 2010. Statistical analysis was performed using R software version 2013 (R Development Core Team, Vienna, Austria).

Results

Fourteen studies were included in the statistical analysis (Table 1). They were conducted between 1991 and 2012 and included 70 723 participants. Age-specific prevalence estimates of the different visual end points in the participating studies are presented in Figure 1. The prevalence of nonrefractive visual impairment strongly increased with age in all studies. For nonrefractive blindness, increasing prevalence with age was not so obvious in some studies, but this was mainly because of the low number of affected participants, particularly in the older age groups. A significant interstudy variability in age-specific prevalence estimates was observed, again especially in the older age groups.

In Table 2, we estimated age-standardized prevalence rates of visual end points according to several factors (gender, period of eye examination, and geographical area). The prevalence of all visual end points tended to be somewhat higher in women, but the confidence intervals (CIs) largely were overlapping with those of men. Age-standardized prevalence rates of all visual end points were much lower in the most recent period (2007–2012) in comparison with the older studies (1991–2006). Indeed, the prevalence of nonrefractive visual impairment (WHO standard) decreased from 2.22% to 0.92% ($P = 0.02$). As shown in Figure 2, the differences were more pronounced in the older participants, and particularly striking was that, in individuals 85 years of age or older, the prevalence of nonrefractive visual impairment (WHO standard) was 15.69% before 2006 and 4.39% after 2006. Similarly, in this age group, prevalence of nonrefractive blindness was 3.26% before 2006 and 0.82% after 2006. By contrast, we observed no clear difference of prevalence of visual impairment and blindness among Northern, Western, and Southern Europe (for instance, for nonrefractive visual impairment: 1.64%, 1.55%, and 1.53%, respectively; $P = 0.40$).

In Table 3, we estimated the prevalence rates and their 95% CIs for each age and gender strata from 1991 through 2006 and from

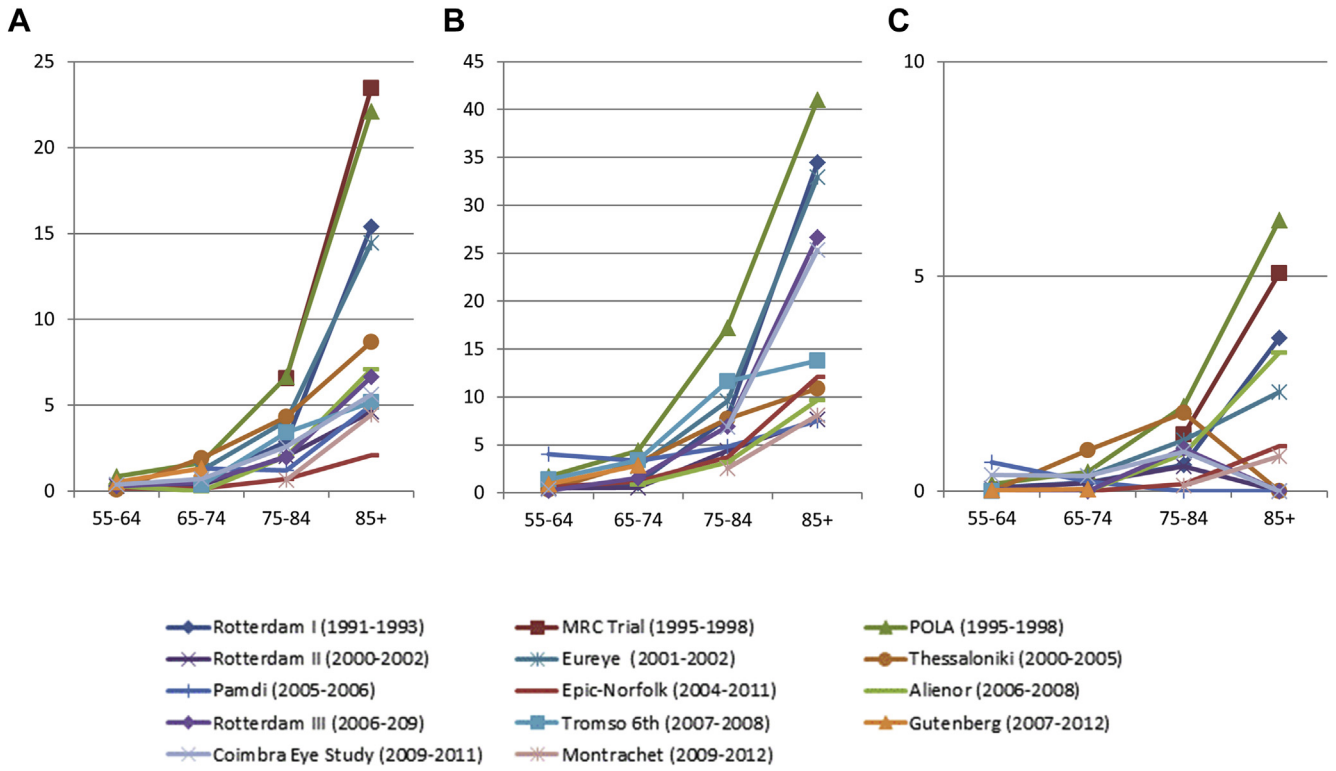

Figure 1. Graphs showing the prevalence (in percent) of nonrefractive visual impairment according to age in studies participating to the European Eye Epidemiology Consortium: (**A**) nonrefractive visual impairment (best-corrected visual acuity [BCVA] <20/60), (**B**) nonrefractive visual impairment (BCVA <20/40), and (**C**) nonrefractive blindness (BCVA <20/400). MRC = Medical Research Council; POLA = Pathologies Oculaires Liées à l'Age.

2007 through 2012. Women showed higher prevalence rates of all visual end points in studies performed before 2006, in particular in participants older than 85 years (for instance, for nonrefractive visual impairment, 21.45% in women versus 13.11% in men; $P = 0.08$). However, the difference was less pronounced in the more recent studies, with very similar prevalence rates in men and women in most age categories (for instance, for nonrefractive visual impairment in the 85 years of age and older category, 3.93% in women versus 4.03% in men; $P = 0.40$).

In Table 4, we estimated the total number of inhabitants of European high-income countries affected by nonrefractive visual impairment and blindness in 2000 and 2010. Although the total number of participants 55 years of age or older increased from 106 million in 2000 to 123 million in 2010, the number of participants

Table 2. Age-Standardized Prevalence Estimates in Participants 55 Years of Age or Older, Stratified by Gender, Period, and Geographical Area

	Nonrefractive Visual Impairment (World Health Organization Definition: Best-Corrected Visual Acuity <20/60)		Nonrefractive Visual Impairment (United States Definition: Best-Corrected Visual Acuity <20/40)		Nonrefractive Blindness (Best-Corrected Visual Acuity <20/400)	
	%	95% Confidence Interval	%	95% Confidence Interval	%	95% Confidence Interval
Gender						
Men	1.38	0.72–2.03	3.17	1.98–4.36	0.32	0.12–0.52
Women	1.81	0.96–2.66	4.24	2.65–5.83	0.39	0.17–0.62
Period						
1991–2006	2.22	1.34–3.10	4.68	2.68–6.68	0.53	0.24–0.81
2007–2012	0.92	0.42–1.42	2.86	1.52–4.20	0.13	0.01–0.26
Geographical area						
Northern countries*	1.64	0.34–2.93	3.90	1.46–6.33	0.38	0.00–0.79
Western countries†	1.55	0.70–2.41	3.67	1.49–5.85	0.33	0.10–0.56
Southern countries‡	1.53	0.65–2.42	3.99	2.79–5.19	0.54	0.08–1.00

*United Kingdom, Norway, and Estonia.
†France, Germany, and The Netherlands.
‡Greece, Italy, and Portugal.

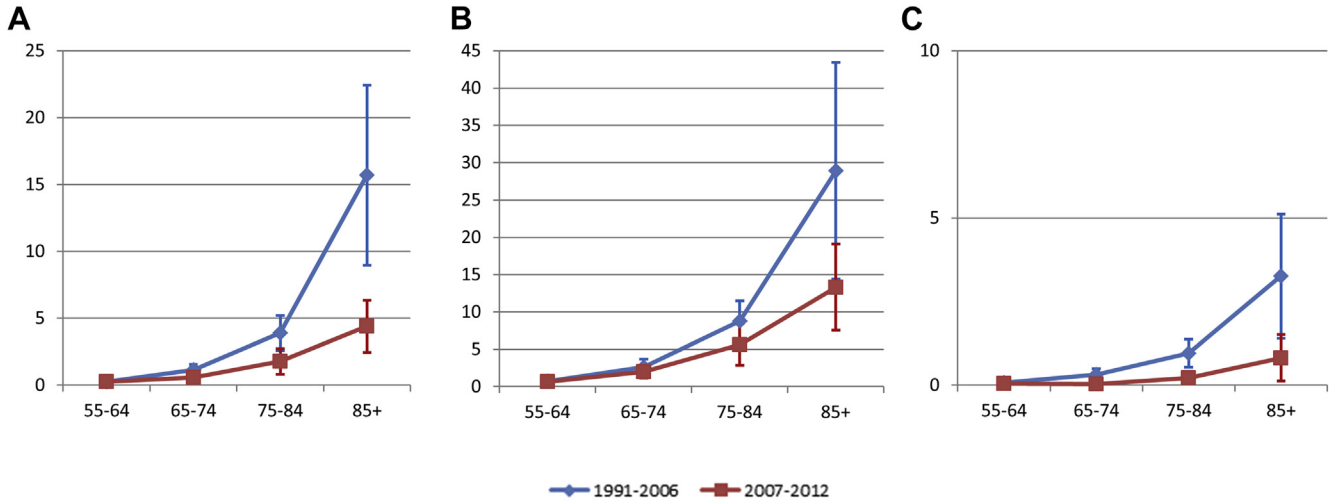

Figure 2. Graphs showing the prevalence (in percent) of nonrefractive visual impairment according to age and period (nonrefractive visual impairment): (**A**) nonrefractive visual impairment with best-corrected visual acuity (BCVA) worse than 20/60, (**B**) nonrefractive visual impairment with BCVA worse than 20/40, and (**C**) nonrefractive blindness (BCVA <20/400).

affected by nonrefractive visual impairment decreased from 2.5 to 1.2 million (5.2 to 3.8 million when using the United States standard). Similar decreases were observed for nonrefractive blindness (from 584 000 to 170 000).

Discussion

This study, which summarized published and unpublished data from 14 studies performed in Europe from 1991 to 2012, provided evidence for a major decrease in the prevalence of nonrefractive visual impairment and blindness in older Europeans in recent years. The age-standardized prevalence of nonrefractive visual impairment in people 55 years of age or older decreased from 2.22% from 1991 through 2006 to 0.92% from 2007 through 2012. It tended to be higher in women than men from 1991 through 2006 (2.67% vs. 1.88%), but not from 2007 through 2012 (0.87% vs. 0.88%). No differences were observed according to geographical area. The projected numbers of affected older inhabitants in European high-income countries decreased from 2.5 million affected participants in 2000 to 1.2 million affected participants in 2010.

In a meta-analysis of population-based studies from high-income countries (including the United States, Australia, and Europe) performed in the 1990s, the prevalence rates for nonrefractive visual impairment according to United States standards (BCVA <20/40) were very similar to our estimates, varying from 0.56% in participants 55 to 59 years of age to 23.73% in participants 80 years of age or older[16] (in comparison with 0.72% in participants 55–64 years of age to 28.95% in those 85 years of age or older for the 1991–2006 period in the present study). In the National Health and Nutrition Examination Study, the prevalence of nonrefractive visual impairment (BCVA <20/40) in non-Hispanic white persons 60 years of age or older was 3.9% (95% CI, 3.3%–4.6%) from 1999 through 2002, increasing to 4.5% (95% CI, 3.6%–5.3%) from 2006 through 2008.[19] We observed a similar estimate from 1991 through 2006 (4.68%; 95% CI, 2.68%–6.68%) for the period of 1991 through 2006, with largely overlapping CIs, but a lower estimate from 2007 through 2012 (2.86%; 95% CI, 1.52%–4.20%).[19] This difference may be the result of different temporal trends in Europe and the United States (with stability or even increase in the United States, contrasting with decrease in Europe) or to the fact that the decrease in prevalence of nonrefractive visual impairment has happened after 2008, and thus was not observed in the National Health and Nutrition Examination Study. To our knowledge, there are no available estimates of the prevalence of visual impairment in the United States after 2008. However, the GBD meta-analysis is also in favor of a decreasing prevalence of visual impairment in North America (from 3.5% in 1990 to 2.5% in 2010 for presenting visual acuity [PVA] <20/60).[26]

The results of the GBD meta-analysis are not directly comparable with those of the present study because they were based on PVA, thus including visual impairment because of refractive errors. However, the temporal trends were similar to those found in our study. Indeed, in the GBD study, the prevalence of visual impairment and blindness (PVA <20/60 and PVA <20/400, respectively) decreased worldwide from 1990 to 2010.[25] This was in particular the case in European high-income countries, with a prevalence of visual impairment in participants 50 years of age or older estimated at 6.2% (95% CI, 4.3%–9.5%) in 1990 and 3.9% (95% CI, 2.8%–6.6%) in 2010.[26] Because they estimated that 47% of visual impairment was the result of refractive errors at both time points, their estimates seem somewhat higher than ours (2.22% and 0.92% for nonrefractive visual impairment and blindness, respectively).

In this study, the prevalence of nonrefractive visual impairment also was halved in the most recent period (2.22% in 1991–2006 compared with 0.92% in 2007–2012). This suggests that visual impairment resulting from eye diseases has decreased with time. Unfortunately,

Table 3. Estimated Prevalence of Nonrefractive Visual Impairment and Blindness Stratified by Age, Gender, and Period

	Studies Performed from 1991 through 2006						Studies Performed from 2007 through 2012					
	Nonrefractive Visual Impairment (World Health Organization Definition: Best-Corrected Visual Acuity <20/60)		*Nonrefractive Visual Impairment (United States Definition: Best-Corrected Visual Acuity <20/40)*		*Nonrefractive Blindness (Best-Corrected Visual Acuity <20/400)*		*Nonrefractive Visual Impairment (World Health Organization Definition: Best-Corrected Visual Acuity <20/60)*		*Nonrefractive Visual Impairment (United States Definition: Best-Corrected Visual Acuity <20/40)*		*Nonrefractive Blindness (Best-Corrected Visual Acuity <20/400)*	
Category	%	*95% Confidence Interval*	%	*95% Confidence Interval*	%	*95% Confidence Interval*	%	*95% Confidence Interval*	%	*95% Confidence Interval*	%	*95% Confidence Interval*
Men												
55–64	0.30	0.00–0.63	0.49	0.18–0.80	0.12	0.00–0.26	0.31	0.16–0.45	0.62	0.31–0.93	0.07	0.00–0.15
65–74	0.90	0.48–1.32	2.25	1.33–3.18	0.31	0.15–0.48	0.48	0.15–0.82	1.68	1.10–2.26	0.06	0.00–0.15
75–84	3.28	2.30–4.26	7.24	5.26–9.21	0.76	0.35–1.17	1.76	0.58–2.93	4.55	1.96–7.14	0.31	0.05–0.56
85+	13.11	5.79–20.44	28.71	19.89–37.54	2.52	0.00–5.32	4.03	1.52–6.53	14.17	5.61–22.73	1.02	0.00–2.30
Age-standardized prevalence*	1.88	0.96–2.81	4.14	2.78–5.51	0.46	0.09–0.83	0.88	0.33–1.44	2.58	1.21–3.94	0.17	0.00–0.37
Women												
55–64	0.18	0.03–0.33	0.76	0.14–1.38	0.07	0.00–0.17	0.20	0.00–0.40	0.68	0.21–1.15	0.04	0.00–0.13
65–74	1.22	0.67–1.77	2.78	1.54–4.01	0.32	0.14–0.50	0.73	0.13–1.33	2.56	1.58–3.54	0.04	0.00–0.11
75–84	4.38	2.60–6.16	9.73	6.47–12.98	1.11	0.72–1.49	1.57	0.70–2.44	5.84	2.77–8.92	0.16	0.00–0.33
85+	21.45	15.80–27.09	38.67	34.31–43.03	4.97	3.63–6.30	3.93	1.03–6.83	12.99	5.37–20.62	0.86	0.07–1.72
Age-standardized prevalence*	2.67	1.73–3.61	5.54	3.97–7.11	0.66	0.41–0.92	0.87	0.24–1.50	3.06	1.46–4.65	0.12	0.00–0.26
Total												
55–64	0.26	0.12–0.41	0.72	0.19–1.25	0.08	0.00–0.15	0.26	0.11–0.41	0.67	0.28–1.06	0.05	0.00–0.14
65–74	1.13	0.70–1.57	2.64	1.61–3.67	0.32	0.16–0.49	0.58	0.18–0.98	1.99	1.17–2.81	0.03	0.00–0.08
75–84	3.90	2.59–5.21	8.77	6.04–11.51	0.95	0.52–1.37	1.77	0.81–2.73	5.65	2.85–8.44	0.22	0.07–0.38
85+	15.69	8.96–22.43	28.95	14.44–43.46	3.26	1.40–5.12	4.39	2.45–6.34	13.32	7.56–19.08	0.82	0.12–1.51
Age-standardized prevalence*	2.22	1.34–3.10	4.68	2.68–6.68	0.53	0.24–0.81	0.92	0.42–1.42	2.86	1.52–4.20	0.13	0.01–0.26

*Standardized to the European Standard Population of 2010.

Table 4. Estimated Number of Participants Affected by Nonrefractive Visual Impairment and Blindness in European High-Income Countries

	Population of European High-Income Countries*	Nonrefractive Visual Impairment (Best-Corrected Visual Acuity <20/60)		Nonrefractive Visual Impairment (Best-Corrected Visual Acuity <20/40)		Nonrefractive Blindness (Best-Corrected Visual Acuity <20/400)	
	No. (Thousands)	*No. (Thousands)*	*95% Confidence Interval*	*No. (Thousands)*	*95% Confidence Interval*	*No. (Thousands)*	*95% Confidence Interval*
Year 2000							
55–64	43 061	112	51–176	310	82–538	34	0–65
65–74	35 299	399	247–554	931	568–1295	113	56–173
75–84	20 587	803	533–1072	1805	1243–2369	195	107–282
85+	7404	1162	663–1661	2143	1069–3218	241	104–379
Total	106 352	2475	1495–3464	5191	2962–7421	584	267–899
Year 2010							
55–64	49 452	128	54–202	331	138–524	25	0–69
65–74	38 635	224	69–378	769	452–1085	12	0–31
75–84	25 958	459	210–708	1466	739–2191	57	18–99
85+	9355	411	229–593	1246	707–1785	76	11–141
Total	123 400	1223	563–1883	3813	2037–5586	170	29–340

*Andorra, Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.

causes of visual impairment and blindness were available only in some of the included studies, mainly because of incomplete eye examinations in many studies (in particular absence of assessment of lens opacities, impeding the diagnosis of cataract, and absence of visual field testing, impeding the diagnosis of glaucoma, which are leading causes of visual impairment). The decrease in nonrefractive visual impairment most likely is the result of improvement in ophthalmologic care over the last 20 years, with easier access to eye care professionals in most European countries and better reimbursement of medical expenses. In particular, both surgical procedures for cataract surgery and intraocular lenses have improved over the last 20 years, increasing their availability, safety, and results in terms of visual acuity. Indeed, the proportion of visual impairment resulting from cataract has been reported to decrease in the last 20 years worldwide, and in particular in industrialized countries.[14] Moreover, new ocular therapies have been developed in this period, including intravitreal injections of anti–vascular endothelial growth factor agents for exudative macular diseases (neovascular AMD, diabetic macular edema, and macular edema resulting from retinal vein occlusion), which were introduced in 2006.[30–32] These therapies have led to major improvements in the visual prognosis of these diseases and most likely contribute to a decrease in the overall prevalence of visual impairment. For instance, a decrease of 50% of the incidence of blindness resulting from AMD has been reported in Denmark, mainly after the introduction of intravitreal therapies for AMD in 2006.[33]

Finally, a decrease in the prevalence of eye diseases themselves may have contributed to a decrease in the prevalence of visual impairment. Indeed, it is now clear that the prevalences of diabetic retinopathy and diabetic macular edema have decreased after 2000, probably because of improvements in the management of diabetes (although this may be compensated partly by an increase in the prevalence of diabetes itself).[34] Two American studies and a meta-analysis in Europe, based on the E^3 consortium, also have suggested that the prevalence of AMD may be lower in more recent generations.[35–37]

Similar trends have been observed in the decrease of the prevalence of other age-related disorders, in particular dementia.[38–40] This suggests that recent generations are aging differently, which is probably the result of multiple causes, such as changes in education, living conditions, lifestyle habits (smoking, nutrition, physical activity), and medical care. In particular, generations born after World War II, who are now entering old age, have experienced quite different living and nutritional conditions than those born before World War II and may age differently. Although it is usually projected that the number of disabled older individuals will grow dramatically in future years because of the aging population, recent reports, including ours, suggest that these projections may be overly pessimistic. In this changing environment, epidemiologic studies need to be repeated to monitor the trends in the prevalence of age-related disorders and related disability.

Similarly to other reports, women tended to have higher age-standardized prevalence rates of visual impairment and blindness, although this was observed mainly in the first period (1991–2006). In the GBD meta-analysis, the prevalence of visual impairment was higher in women than in men in all world regions.[25] In the National Health and Nutrition Examination Study, women showed higher prevalence rates of visual impairment, both from 1999 through 2002 (1.5% for women vs. 1.2% for men) and from 2006 through 2008 (1.9% for women vs. 1.5% for men), but these differences did not reach statistical significance after adjustment for age, ethnicity, poverty, education, health insurance, and diabetes. Reasons for these potential differences in visual impairment among men and women are unclear, and the differences seem to have decreased in the more recent years in Europe.

The E^3 consortium has provided a large data set to meta-analyze temporal trends for prevalence of visual impairment across Europe. One of the strengths is that this meta-analysis was built not only on published data, but also on unpublished data, which have not been included in previous estimates. The size of the dataset is much larger than in previous meta-analyses of European participants, in particular for the most recent period (2007−2012). For instance, the GBD meta-analysis included only 2 European studies conducted in this period, both performed in Spain and totaling 1600 participants, whereas for the same period, the present meta-analysis included 6 studies from 7 European countries, totaling more than 36 000 participants. The estimates also were derived from raw data provided by each study following standardized procedures, in particular in the definition of the different visual end points.

Limitations of this consortium meta-analysis include heterogeneity between studies. Contributing studies inherently differed in study design and cohort sampling. To overcome this, we performed a random-effects rather than a fixed-effects meta-analysis, assuming no different true effects between studies. There are also differences between European countries in terms of urbanization, economy, social class, education, and lifestyle that are known to influence eye diseases. Data on these variables at an individual or study-specific level were not available uniformly, and therefore could not be included in the present study.

Representativeness of the population samples also is probably heterogeneous among studies. To assess whether the lower prevalence rates observed in the most recent studies may be the result of a lower representativeness of those studies, we performed analyses limited to the 3 most representative studies of the 2007 through 2012 period (the Rotterdam III Study, Tromsø 6th Study, and Coimbra Eye Study). The prevalence of nonrefractive visual impairment was similar in this subgroup (1.17%; 95% CI, 0.66%−1.67%), as in the main analysis for the 2007 through 2012 period (0.83%; 95% CI, 0.38%−1.28%), and lower than in the studies performed from 1991 through 2006 (2.22%; 95% CI, 1.34%−3.10%).

Although the E^3 consortium strives to include a maximum of European research groups involved in ophthalmic epidemiology, participating studies were mostly from European high-income countries, whereas no studies from Central and Eastern Europe could be included, except for a small sample from Estonia. To our knowledge, only very few epidemiologic studies including measurements of visual acuity have been conducted in Central and Eastern Europe. For instance, only 3 such studies were included in the GBD meta-analysis (including the sample from Estonia, which is also included in our meta-analysis).[26] However, the available data suggest that the prevalence of visual impairment and blindness may be higher in Central and Eastern Europe than in European high-income countries.[26] Thus, we decided not to extrapolate our findings to those areas of Europe. Epidemiologic studies conducted in these areas of Europe would be particularly informative.

In addition, as shown in Table 1, most participating studies collected data only for participants 55 years of age or older. Therefore, we could not estimate the prevalence of visual impairment in persons younger than 55 years. Finally, most participating studies included only measures of BCVA, but not of presenting visual impairment, so it was possible to estimate only the prevalence of nonrefractive visual impairment. The causes of visual impairment also generally were not available. Future European epidemiologic studies should strive to include measures of presenting visual acuity and to determine the causes of visual impairment to give a more complete description of the epidemiologic features of visual impairment in Europe. In particular, uncorrected refractive errors represent a major cause of visual impairment and blindness worldwide, including in Europe.[14]

In conclusion, this meta-analysis supported a decrease in the prevalence and numbers of older Europeans affected by nonrefractive visual impairment and blindness in the last 20 years. This decrease may be the result of major improvements in eye care, a generation effect on eye disease incidence, or both. These findings underline the need for continuing epidemiologic monitoring of the temporal trends of ocular health in Europe.

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Abbreviations and Acronyms:
AMD = age-related macular degeneration; **BCVA** = best-corrected visual acuity; **CI** = confidence interval; **E^3** = European Eye Epidemiology; **GBD** = Global Burden of Diseases, Injuries and Risk Factors; **PVA** = presenting visual acuity; **WHO** = World Health Organization.

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