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Increasing Prevalence of Myopia in Europe and the Impact of Education

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Purpose: To investigate whether myopia is becoming more common across Europe and explore whether increasing education levels, an important environmental risk factor for myopia, might explain any temporal trend.

Design: Meta-analysis of population-based, cross-sectional studies from the European Eye Epidemiology (E^3) Consortium.

Participants: The E^3 Consortium is a collaborative network of epidemiological studies of common eye diseases in adults across Europe. Refractive data were available for 61 946 participants from 15 population-based studies performed between 1990 and 2013; participants had a range of median ages from 44 to 78 years.

Methods: Noncycloplegic refraction, year of birth, and highest educational level achieved were obtained for all participants. Myopia was defined as a mean spherical equivalent ≤ -0.75 diopters. A random-effects meta-analysis of age-specific myopia prevalence was performed, with sequential analyses stratified by year of birth and highest level of educational attainment.

Main Outcome Measures: Variation in age-specific myopia prevalence for differing years of birth and educational level.

Results: There was a significant cohort effect for increasing myopia prevalence across more recent birth decades; age-standardized myopia prevalence increased from 17.8% (95% confidence interval [CI], 17.6–18.1) to 23.5% (95% CI, 23.2–23.7) in those born between 1910 and 1939 compared with 1940 and 1979 ($P = 0.03$). Education was significantly associated with myopia; for those completing primary, secondary, and higher education, the age-standardized prevalences were 25.4% (CI, 25.0–25.8), 29.1% (CI, 28.8–29.5), and 36.6% (CI, 36.1–37.2), respectively. Although more recent birth cohorts were more educated, this did not fully explain the cohort effect. Compared with the reference risk of participants born in the 1920s with only primary education, higher education or being born in the 1960s doubled the myopia prevalence ratio–2.43 (CI, 1.26–4.17) and 2.62 (CI, 1.31–5.00), respectively—whereas individuals born in the 1960s and completing higher education had approximately 4 times the reference risk: a prevalence ratio of 3.76 (CI, 2.21–6.57).

Conclusions: Myopia is becoming more common in Europe; although education levels have increased and are associated with myopia, higher education seems to be an additive rather than explanatory factor. Increasing levels of myopia carry significant clinical and economic implications, with more people at risk of the sight-threatening complications associated with high myopia. *Ophthalmology 2015;122:1489-1497 © 2015 by the American Academy of Ophthalmology. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).*

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Myopia (near-sightedness) occurs when a distant object's image is formed anterior to the retinal plane, most commonly as a result of an increased axial length. This results in blurred distant vision and, unlike hyperopia, requires refractive correction at all ages and severity for clear focus. Myopia is already the most common eye condition worldwide, but the prevalence is significantly increasing, especially in Southeast Asia.[1–3] In Europe, Australia, and the United States, the

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prevalence of myopia seems to be lower[4,5]; however, there is evidence of an increasing prevalence in the United States and elsewhere,[6–8] particularly among young adults.[9] This is of concern because myopia, even when appropriately corrected, is associated with an increased risk of sight-threatening diseases, such as myopic maculopathy, retinal detachment, glaucoma, and cataract.[10] Myopic maculopathy is currently untreatable and already contributes to visual impairment in working-age adults.[11] Increasing myopia levels in Europe carry implications for public health policy in both the provision of clinical services and the economic sequelae from the resulting visual impairment among the working population.

Myopia is a highly heritable trait,[12,13] and to date a number of genetic polymorphisms have been associated with refractive error, albeit explaining only a small proportion of this heritability.[14,15] Environmental factors play a key role in myopia development and must explain the recent changes in prevalence.[16] Myopia has been associated with education, near work, urbanization, prenatal factors, socioeconomic status, cognitive ability, season of birth, light, and time spent outdoors.[2,16–25] One of the strongest and most replicated risk factors is educational attainment,[16,26] and there is some evidence of interaction between genetic factors and education influencing the risk of myopia.[27] The increased levels of higher education over the 20th century[28] might be a causative factor, or marker of a causative factor, for increasing myopia prevalence.

The aims of this study are to identify whether myopia is becoming more common across Europe and to examine whether increasing levels of education explain any temporal trend, using data from more than 60 000 participants from the European Eye Epidemiology (E^3) Consortium.

Methods

Study Population

The E^3 consortium is a collaborative initiative to share and meta-analyze epidemiologic data on common eye diseases across Europe. Thirty-three studies are currently part of the consortium, and a range of ophthalmic data are available on approximately 124 000 individuals from population-based and case-control cohorts. All studies adhere to the tenets of the Declaration of Helsinki, and relevant local ethical committee approvals with specific study consent were obtained.

Refractive error measurements from 68 350 adults within the 15 E^3 population-based studies that had data on refractive error were included. These included population-based cross-sectional or cohort studies, with 2 studies recruiting participants nationally and 13 studies recruiting from a local population. Further details on each study are provided in Table 1 and the Supplementary information (available at www.aaojournal.org). Exclusion criteria included subjects who had cataract or refractive surgery, retinal detachment, or other conditions, such as keratoconus, which might influence refraction (n = 6404). Data on age at refraction and birth year were available for 61 946 individuals, with information on education level for 60 125 subjects. Participants were mainly middle to late age; 98% were of European descent (where ethnicity was known), predominantly from Northern and Western Europe; and refractive examinations were performed from 1990 to 2013 (Table 1).

Study Variables

Noncycloplegic refractions were performed on all individuals using subjective refraction, autorefraction, or a combination of focimetry with subjective refraction. Spherical equivalent was calculated using the standard formula (spherical equivalent = sphere + [cylinder/2]). Myopia was defined as ≤ -0.75 diopters. Myopia prevalence by age was calculated, using 5- and 10-year age bands from $\geq$15 years to $\geq$90 years. To study the impact of education on myopia, given the variation in educational systems across Europe, we established a simplified 3-tier level of education across all cohorts. Primary education was defined as those leaving school before 16 years of age, secondary education was defined as those leaving education up to the age of 19 years, and higher education was defined as those leaving education at or after the age of 20 years. Those aged younger than 20 years at the time of refraction (and therefore unable to have reached the highest education tier) were excluded from this analysis to avoid misclassification bias.

We investigated the evidence for a cohort effect on increasing myopia prevalence by observing variations in myopia prevalence within defined age bands. These analyses are focused on the age range constituting the majority of our cohort (40–80 years of age, birth year 1910–1979, n = 56 088), meaning the youngest and oldest participants, for whom we had no comparative birth cohort, were not considered. Prevalence between different birth cohorts was examined, initially using decade bins (1910–1970) and subsequently in 2 birth cohort groups divided by the median birth decade (1940–1949). Finally we examined the influence of education by examining the myopia prevalence between birth cohorts with the additional stratification of educational status.

Statistical Analysis

Study-specific summary data for myopia prevalence were obtained and combined in a random-effect meta-analysis stratified by age. A random-effects model was chosen over a fixed-effects model to allow for expected heterogeneity between studies as a result of varying study design. Age was standardized with demographic distribution adjustments to age-specific estimates according to the European Standard Population 2010.[29] Evidence for the presence of a cohort effect was investigated using random-effect meta-analyses of myopia prevalence stratified by age and birth year, and subsequently age, birth year, and educational level. Differences between estimates of myopia prevalence were evaluated using the analysis of variance test, proportion z tests, and prevalence ratios (relative difference in prevalence against a defined baseline). Differences were considered significant at $P < 0.05$.

Statistical analysis was performed using Stata statistical software version 13.1 (StataCorp LP, College Station, TX). Graphical outputs[30] were obtained using Stata, Origin version 9.0 (OriginLab Corp, Northampton, MA), or ggplot2(30) in R software (R Foundation for Statistical Computing, Vienna, Austria; available at http://www.R-project.org).

Results

In this meta-analysis of 61 946 adults, the overall myopia prevalence was 24.3% (95% confidence interval [CI], 20.1–28.5), with an age-standardized prevalence in Europe of 30.6% (95% CI, 30.3–30.8). Age-stratified analyses[31] revealed a high prevalence in young adults (47.2% [95% CI, 41.8–52.5] in those aged 25–29 years), which was almost double the prevalence in those of middle to older age (27.5% [95% CI, 23.5–31.5] in those aged 55–59 years). There were no significant differences in the myopia prevalence by gender.[31]