AMERICAN ACADEMY OF OPHTHALMOLOGY®

Reducing the Global Burden of Myopia by Delaying the Onset of Myopia and Reducing Myopic Progression in Children

The Academy's Task Force on Myopia

Bobeck S. Modjtahedi, MD,[1,2] Richard L. Abbott, MD,[3] Donald S. Fong, MD,[1,2] Flora Lum, MD,[4] Donald Tan, MD,[5] on behalf of the Task Force on Myopia

In 2019, the American Academy of Ophthalmology (AAO) created the Task Force on Myopia in recognition of the substantial global increases in myopia prevalence and its associated complications. The Task Force, led by Richard L. Abbott, MD, and Donald Tan, MD, comprised recognized experts in myopia prevention and treatment, public health experts from around the world, and organization representatives from the American Academy of Family Physicians, American Academy of Optometry, and American Academy of Pediatrics. The Academy's Board of Trustees believes that myopia is a high-priority cause of visual impairment, warranting a timely evaluation and synthesis of the scientific literature and formulation of an action plan to address the issue from different perspectives. This includes education of physicians and other health care providers, patients and their families, schools, and local and national public health agencies; defining health policies to ameliorate patients' access to appropriate therapy and to promote effective public health interventions; and fostering promising avenues of research. *Ophthalmology 2021;128:816-826 © 2020 by the American Academy of Ophthalmology*

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Myopia is a common ocular condition and an increasing cause of visual impairment globally. Myopia prevalence has been rising over the past several decades, especially in East Asia, with projections of even greater growth in the next 50 years. Holden et al[1] estimated that the number of myopic individuals (−0.50 diopter [D] or more myopia) and the prevalence of myopia would grow from 1406 million people (22.9% of the population; 95% confidence interval [CI], 932−1932 million [15.2%−31.5%]) in 2000 to 4758 million people (49.8% of the population; 95% CI, 3620−6056 million [43.4%−55.7%]) in 2050 (Fig 1). Similar growth was predicted for those with high myopia (≥−5.00 D or more myopia): from 163 million people (2.7% of the population; 95% CI, 86−387 million [1.4%−6.3%]) to 938 million people (9.8% of the population; 95% CI, 479−2104 million [5.7%−19.4%]).

Although the vision loss resulting from refractive error can usually be addressed with spectacles or contact lenses, the anatomic changes (i.e., longer ocular axial length) associated with myopia increase a patient's risk of uncorrectable visual impairment developing throughout life, especially with advanced age.[2] Higher degrees of myopia are associated with greater risks for complications and subsequent vision loss.[2] By 75 years of age, 3.8% of those with myopia (0.50 to −6.00 D myopia) and 39% of those with high myopia (−6.00 D or more myopia) among Dutch individuals have uncorrectable visual impairment.[2] Myopia increases the risk of retinal detachment, cataract, glaucoma, staphyloma, myopic macular degeneration, and myopic choroidal neovascularization. It is projected that uncorrectable visual impairment resulting from myopia will increase 7 to 13 times in high-risk areas by 2055.[2] The public health burden posed by myopia extends beyond the direct costs associated with the optical correction of refractive error and includes the socioeconomic impacts[3] and diminished qualify of life[4−6] associated with visual impairment. The increasing prevalence of myopia and corresponding clinical and societal impacts necessitate a coordinated global response.

In February 2019, in recognition of this public health concern, the American Academy of Ophthalmology's Board of Trustees determined that the American Academy of Ophthalmology (AAO) would take a leading role in addressing the need to combat the development and progression of myopia on a global basis. As a first step, the Board of Trustees created the Task Force on Myopia comprising experts in myopia from around the world to develop an evidence-based white paper on the rationale for early intervention, including approaches to control myopia progression and to outline next steps to address this public health problem. The Task Force was organized in the spring

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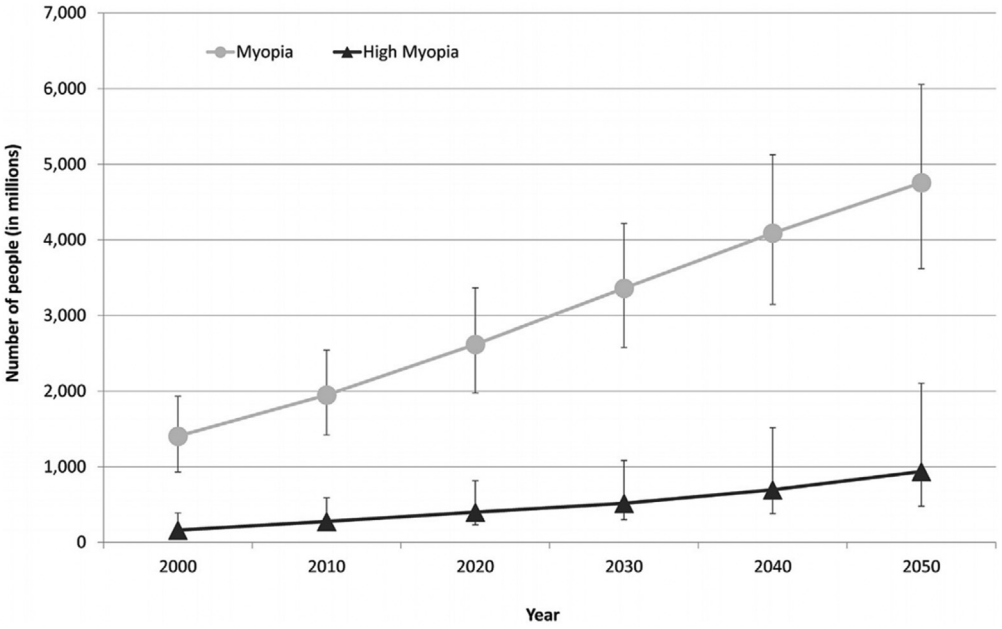

Figure 1. Line graph showing the number of people estimated to have myopia and high myopia for each decade from 2000 through 2050. Error bars represent the 95% confidence intervals. Holden BA, Fricke TR, Wilson DA, et al. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. *Ophthalmology*. 2016;123(5):1036–1042.

of 2019, reviewed the scientific literature over the summer of 2019, met in person in October 2019, and held subsequent online discussions and idea exchanges throughout the spring of 2020. The primary aim of the Task Force was to explore how the Academy could serve best as a resource to slow the development and progression of myopia. The Task Force's intent for this report is not to duplicate recent rigorous scientific reviews of the genetics, prevalence, economic costs, and epidemiologic features of myopia or of the effectiveness and safety of various interventions for reducing myopia progression. Instead, the goals of the Task Force are to provide a broad-based overview of the current scientific evidence and focus on the initiation and support of public health interventions that address this important issue in a thoughtful, concerted, and systematic manner.

The goal of the Task Force's recommendations is to reduce the global burden of myopia by delaying the onset of myopia and reducing myopic progression in children and adolescents, with the hopes of preventing the more severe consequences of higher levels of myopia. The objectives of the Task Force are to help define the role of the Academy in addressing this important public health problem by:

1. Educating the health care community, public policy makers, and the general public about the public health burden imposed by myopia.
2. Assisting in the development of broad public health initiatives to prevent the onset and progression of myopia, including working with parents and educational authorities to create school-based programs that incorporate and maintain educational standards while leveraging the benefit of outdoor time.
3. Fostering collaboration among researchers, health care organizations, and industry internationally to develop novel interventions for myopia control.

Epidemiology of Myopia and Future Trends Globally

Risk Factors for Myopia

Myopia is a multifactorial condition with both genetic and environmental components. The increasing prevalence of myopia points toward environmental influences such as the role of urbanization and reduced outdoor exposure as keys to myopia development. Certain populations, especially within East Asia, seem particularly at risk of myopia.[7–10] The marked rise in myopia prevalence in East Asia seems to be driven primarily by more severe environmental exposures (e.g., high educational pressures combined with less outdoor time).[11] Several risk factors for myopia have been studied, including gender, race and ethnicity, outdoor time, near-work activity, socioeconomic status, education level, body mass index, exercise and activity level, and diet, with varying degrees of supporting evidence.[12]

Studies examining the role of near work in myopia onset and progression have produced inconsistent results, whereas the relationship between increased outdoor time and reduced myopia onset is established more firmly.[12–14] An association between myopia and education has long been observed anecdotally, with supporting observational studies.[15–20] The bidirectional, 2-sample Mendelian randomization study by Mountjoy et al[16] provided strong causal evidence that exposure to more years of education contributes to a rise

in the prevalence of myopia.[16] The authors found that each additional year of education was associated with 0.18-D more myopic refractive error. Important environmental factors, including the degree of urbanization, significantly impact the incidence and prevalence of myopia. Children in urban environments are 2.6 times more likely to be myopic compared with those in rural environments when controlling for other factors.[21] Parental myopia is another important risk factor that has been studied, and although it is not modifiable, it may help to identify which children require closer monitoring.[22,23] A study by Liao et al[23] in China found that the children of highly myopic parents had an increased risk of being myopic in adulthood. Additionally, children with myopic parents exhibited faster axial length elongation and myopic progression at an earlier age.

Understanding which children are at the highest risk of progression to high myopia may allow for more targeted intervention. Pärssinen and Kauppinen[24] found that approximately 32% of children who received their first myopic correction with spectacles between 8.8 and 12.8 years of age progressed to high myopia of at least −6.00 D by adulthood. They found that the risk of high myopia in adulthood was associated with a higher degree of baseline myopia, parental myopia, baseline age, more time spent on near work or reading, fewer outdoor activities in childhood, and myopic progression during the first year of onset. Chen et al[25] proposed using a population centile curve, derived from population-based data, to provide an age-specific severity scale that would identify children at risk of high myopia developing in adulthood. Luong et al[26] retrospectively evaluated the trajectory of refractions in a racially and ethnically diverse population of Southern Californian children (n = 11 595) with myopia of between 4 and 11 years of age and an initial refraction of between −1 and −6 D. After adjusting for initial age and follow-up time, East and Southeast Asian children showed greater myopic progression than White children. A simple regression model using age, gender, and baseline refraction data from the Guangzhou Twin Eye Study was able to predict which 12- to 13-year-old children would go on to experience high myopia with an area under the curve of more than 95.[27] Additional modeling efforts are needed to expand our understanding of risk stratification in other populations.

Epidemiologic Features of Myopia in the United States

Epidemiologic studies typically define myopia as a spherical equivalent of at least −0.50 D and high myopia as a spherical equivalent of at least −5.00 D or −6.00 D[28,29]; however, it is important to note that studies that use noncycloplegic refractions overestimate the degree of myopia, especially in children and young adults.[12]

Data from the 1999−2004 National Health and Nutrition Examination Survey (NHANES) suggested that 44.7% of American adults older than 20 years of age were myopic (defined as at least −0.50 D), with 6.5% being highly myopic (defined as at least −5.00 D).[30] Comparison of the 1971−1972 and 1999−2004 NHANES data[31] indicated that the prevalence of myopia increased in people between 12 and 54 years of age during the period between the two surveys (25.0% vs. 41.6%; $P < 0.001$). Although the overall prevalence and degree of myopic error was likely overestimated in this analysis, the same methodology was used in both cohorts.[31] Willis et al's[32] more recent analyses of the NHANES (2005−2008) and the Intelligent Research in Sight Registry estimated that 3.92% of American adults had high myopia.

Theophanous et al[33] provided contemporary estimates of myopia in a Southern California cohort of children 5 to 19 years of age that was broadly representative of the state's demographics. They reported that 41.9% of patients 19 years of age or younger were myopic (at least −1.00 D) and 2.7% of patients demonstrated high myopia (at least −6.00 D). However, because these values are derived from children undergoing routine eye examinations, they are likely higher than the general population. Myopia was more common among Asian and Pacific Islander children (odds ratio, 1.64; 95% CI, 1.58−1.70) and Black children (odds ratio, 1.08; 95% CI, 1.03−1.13) compared with White children.[33] The prevalence of myopia (at least −1.00 D) in children between 6 and 72 months of age, based on cycloplegic autorefraction, among children in Los Angeles was shown to vary based on race, with the highest rates seen in Black children (6.6%), followed by Asian children (3.98%), Hispanic children (3.7%), and non-Hispanic White children (1.20%).[34,35] The parallel study in Baltimore for children 6 to 72 months of age found higher myopia rates in Black children (5.5%) compared with non-Hispanic White children (0.7%).[36] Among American school-aged children, Asian Americans were found to have the highest prevalence of myopia based on cycloplegic autorefraction in 2003:[37] 18.5% compared with 13.2% in Hispanic children, 6.6% in Black children, and 4.4% in White children. However, the lack of large-scale nationwide cycloplegic data, especially among teenagers, limits our understanding of the true prevalence rates in American children. Reed et al[38] found that among recent enlistees in the United States Air Force (69% men; mean age, 20.59 years), 45% were myopic (more than −0.50 D) and 2% demonstrated high myopia (more than −6.00 D).

Epidemiologic Features of Myopia Globally

A 2004 meta-analysis estimated that the crude prevalence of myopia (at least −1.00 D) among adults older than 40 years of age in Western Europe and Australia was 26.6% and 16.4%, with 4.6% and 2.8% having high myopia (at least −5.00 D), respectively.[39] This compared similarly with American adults who showed estimated myopia and high myopia prevalences of 25.4% and 4.5%, respectively.[39] The European Eye Epidemiology Consortium estimated the prevalence of myopia in an ethnically homogenous adult cohort (≥25 and <90 years of age) in which 98% of individuals had European ancestry. Myopia (at least −0.75 D) and high myopia (at least −6.00 D) were present in 30.6% (95% CI, 30.4%−30.9%) and 2.7% (95% CI, 2.69%−2.73%) of adult Europeans, respectively.[40] A 2019 review of the literature from India estimated that myopia

prevalence was 27.7% in adults.[41] The overall myopia detection rate in 31 Chinese provinces was 57.2% (122 965/215 160) among those 7 to 18 years of age.[42]

Significant regional variations exist in estimates of pediatric myopia,[12,21] with East Asians having the highest prevalence at 15 years of age (69%; 95% credible intervals, 61%−77%) compared with Black Africans (5.5%; 95% credible intervals, 3%−9%).[21] Rudnicka et al[21] reported an increase in myopia prevalence by 23% over the preceding decade in East Asia, in contrast to a smaller increase in prevalence in White persons and a less pronounced increase in South Asian persons. The most striking increases in myopia have been seen in East Asia, where the myopia prevalence has grown to 80% to 90% of older school-aged children.[43,44] The prevalence of myopia among 19-year-old male conscripts in Seoul, South Korea was 96.5%, with 21.61% having high myopia.[29] In comparison, 19-year-old men in rural South Korea showed an 83.3% and 6.8% prevalence of myopia and high myopia, respectively.[45] Although the study by Reed et al[38] on United States Air Force enlistees was not representative of the overall United States population, the differences between the American and South Korean cohorts are noteworthy. An analysis of more than 1.5 million Austrian male military conscripts between 1983 and 2017 found that the prevalence of myopia (at least −0.50 D) had increased from 13.8% to 24.4% over 35 years.[46] Interestingly, although those with less education showed a consistently lower prevalence of myopia, they demonstrated a larger increase in myopia prevalence (11.4%−21.7%) than those who received more years of education (24.5%−29.6%) during the study period.[46]

A review of 5 nationwide surveys from Taiwan between 1983 and 2000 found a trend toward individuals becoming myopic at an earlier age, with an average age of 11 years in 1983 compared with an average age of 8 years by 2000.[28] Tsai et al[47] showed that the prevalence of myopia (at least −0.25 D) and high myopia (at least −6.00 D) increased between 1983 and 2016 in school-aged Taiwanese children. Among 12-year-olds, myopia prevalence increased from 30.7% (95% CI, 26.9%−34.4%) to 76.7% (95% CI, 72.9%−80.4%; $P = 0.001$), and high myopia prevalence increased from 1.39% (95% CI, 0.4%−2.4%) to 4.26% (95% CI, 3.4%−5.2%; $P = 0.008$). As of 2016, 90.34% (95% CI, 87.69%−92.99%) and 24.16% (95% CI, 22.20%−26.12%) of 18-year-olds were myopic and highly myopic, respectively.[47] This contrasts with trends in Hong Kong, which has the highest rates of myopia in China, where the prevalence of pediatric myopia has not changed significantly compared with 15 years ago.[48]

An analysis of Australian school-aged children in Sydney provided insight on the interplay of race and environment in myopia prevalence trends.[48] Children were divided into 2 cohorts based on their age at enrollment. The cross-sectional prevalence of myopia was higher at 12 years of age in the younger age cohort than in the older cohort, especially among European White children, indicating that the prevalence of myopia in Australia is increasing. East Asian school children in Australia showed a higher prevalence of myopia than their European White peers (59.1% vs. 17.7%, respectively, among 17-year-olds). Among those with baseline myopia, the rate of progression was low and did not differ among ethnic groups. Compared with prior studies, the prevalence of myopia was less in East Asians living in Australia than in those residing in East Asia and also less for White Australians than White Europeans. The rates of myopic progression were less for East Asians in Australia when compared with rates reported in East Asia, further indicating that the environment may play a role in both myopia onset and progression.[49]

Importance of Myopia and Consequences of High Myopia Globally

Clinical Impact of Myopia

Refractive errors resulting from myopia can usually be corrected with spectacles or contact lenses, although achieving satisfactory vision becomes more challenging with higher degrees of myopia. Anatomic changes in eyes in patients with myopia (i.e., longer axial length) increase the risk of secondary ocular sequelae, which can ultimately lead to uncorrectable visual impairment. Results from the Blue Mountains Eye Study demonstrated an increased risk of cataract[50] and glaucoma[51] in myopic patients. The Eye Disease Case-Control Study Group demonstrated that eyes with −1.00 to −3.00 D refractive error had a 4 times increase in the risk of idiopathic rhegmatogenous retinal detachment, whereas eyes with more than −3.00 D of myopia had a 10 times increased risk compared with non-myopic eyes.[52] Of note, eyes with pathologic myopia were excluded from this study, which may have resulted in an underestimation of retinal detachment risk, especially in those with higher degrees of myopia.

Individuals with myopia, especially those with high myopia, can experience vision loss resulting from degenerative macular changes owing to progressive axial elongation of the globe with resultant chorioretinal atrophy at least as severe as diffuse atrophy.[11,53,54] These changes have been referred to as *pathologic myopia*, *myopic degeneration*, *degenerative myopia*, or *myopic maculopathy*[53] and have a reported prevalence of 0.9% to 3.1%.[11] Among Chinese adults 21 years of age and older, a 1-mm increase in axial length conferred a 10.84% higher risk of pathologic myopic retinopathy as well as a 7.35% higher risk of low vision.[55] Pathologic myopia is an important cause of low vision and blindness, especially in East Asia, where it is responsible for 12.2% to 31.25% of cases of low vision[11,56–59] and was ranked as the most frequent cause of blindness in one Chinese study (19.4%).[60] The Rotterdam Study found that myopic degeneration was the most common cause of visual impairment (25%) among those younger than 75 years of age in The Netherlands.[61] Pathologic myopia was the cause of blindness in 6.0% to 9.1% of people in predominantly White countries, making it the second- to fifth-most common cause of blindness in these populations.[11,61–64] When considering blindness on a per-person basis, myopic degeneration was the third-most common cause in the Los

Angeles Latino Eye Study (12.5%).[65] Willis et al[32] estimated that 0.33% of American adults had progressive high (degenerative) myopia. The Blue Mountains Eye Study found that myopic retinopathy was present in 25.3% of individuals with more than −5.00 D of myopia and in only 0.42% of individuals with less than −5.00 D of myopia. However, although higher degrees of myopia carry a greater risk of visual impairment to the individual, the population-based burden of lower degrees of myopia remains considerable.[66,67] Forty-three percent of myopic retinopathy cases are observed in those with less than −5.00 D of myopia owing to this degree of refractive error being more common than higher degrees of myopia.[66,67] Globally, 10 million individuals are estimated to have visual impairment from myopic macular degeneration, and 3.3 million of them are blind.[68] These numbers are estimated to grow to 55.7 million people with visual impairment and 18.5 million individuals with blindness by 2050, unless new strategies to control myopia are implemented.[68]

Myopic patients may also demonstrate posterior staphylomas (posterior outpouchings of the ocular wall).[53] Mechanical damage to the posterior segment resulting from myopia can also result in a glaucoma-like optic neuropathy.[69,70] Patients with myopia, especially those with patchy atrophy and breaks in Bruch's membrane (lacquer cracks),[71] are at risk for myopic choroidal neovascular membranes, which have been reported in 5.2% to 11.3% of patients with pathologic myopia[11] and are estimated to occur in 0.017% of American adults.[32]

Socioeconomic Impact of Myopia

The socioeconomic impact of myopia is multifactorial and involves the direct costs of refractive correction as well as the indirect costs of lost economic opportunity for those affected and their caregivers. Additionally, costs are associated with expanding ophthalmic infrastructure to accommodate the medical needs of myopic patients (e.g., more trained eye care providers, more clinics). The regional economic impact of myopia varies based on health care resources and use as well as labor force participation, employment patterns, myopia prevalence (including severity), and predominant economic industries and activities.[72] Data from the 1999−2002 NHANES suggest that refractive correction results in normal vision in more than 110 million Americans 12 years of age and older and that it would cost at least $3.8 billion to correct impaired distance vision.[73] Globally, it has been estimated that visual impairment resulting from uncorrected myopia results in $244 billion worth of loss of productivity (95% CI, $49 billion−$697 billion) and that blindness resulting from myopic macular degeneration results in a $6 billion dollar productivity loss (95% CI, $2 billion−$17 billion).[74] The greatest losses in productivity resulting from uncorrected myopia, as a percentage of gross domestic product, are estimated to occur in Southeast Asia (1.35%), South Asia (1.30%), and East Asia (1.27%).[74] It was estimated in 2012 that a 5-year investment of $20 billion would address visual impairment resulting from all forms of uncorrected refractive error.[74] The potential productivity gains from correcting myopia far outweigh the costs, making it a wise global economic investment for both the public and private sectors.[74] Considering the increasing prevalence trends in myopia, further economic benefits are likely to be realized from reducing the prevalence of myopia broadly as well as decreasing the progression of myopia, with a particular focus on reducing the risk of pathologic myopia.

Myopia Control Strategies

Optical, pharmacologic, and behavioral interventions have been attempted for myopia control. Spectacle- and soft contact lens-based approaches that provide myopic defocus of light on the peripheral retina have been used with modest treatment effects.[75,76] Overnight orthokeratology (OOK) reshapes the cornea and allows users to go without their myopic correction during the day. In addition to correcting low to moderate degrees of myopia, myopic progression is reduced, presumably from the induction of myopic defocus on the peripheral retina, which reduces the stimulus for axial length growth. A 2019 AAO Ophthalmic Technology Assessment found that safety remains an important concern because of the risk of potentially blinding microbial keratitis resulting from contact lens wear and because clinical differences are small with other viable and lower-cost interventions.[77] Daily disposable soft bifocal and multifocal contact lenses require less professional expertise and oversight than are required for OOK lens treatment, and they possess similar efficacy in slowing myopia progression. A randomized clinical trial found reduced 3-year myopia progression in children who used high add power soft multifocal contact lenses (−0.60 D) compared with children who used medium add power (−0.89 D) or single-vision (−1.05 D) contact lenses.[78] Postmarket experience with a multifocal soft lens approved for myopia control in the United States in 2019 and other similar lenses should prove informative.

Early studies of topical atropine demonstrated that high doses (0.5%−1%) were effective in slowing myopia progression[79−82]; however, their practical usefulness was limited by photophobia and glare resulting from pupillary dilation and reduced accommodation. Subsequent studies demonstrated moderate reductions in myopic progression from lower doses of atropine (0.01%−0.1%).[83,84] A 2017 AAO Ophthalmic Technology Assessment concluded that although the treatment effect was not as large as that found using higher doses of atropine, a lower dose of atropine (0.01%) resulted in fewer side effects and less rebound myopia after cessation, making it the most reasonable approach to myopia control.[85] In a meta-analysis of 16 different myopia control interventions, Huang et al[75] found that atropine was the most effective treatment method for reducing myopia progression as measured by refraction (Table 1). Yam et al[86] compared low-dose concentrations of atropine (0.05%, 0.025%, and 0.01%) and found that the 2-year efficacy of 0.05% atropine was twice that of 0.01% atropine.

A limitation of all myopia interventions is the lack of long-term follow-up and uncertainty about how different

Table 1. Treatment Effect Relative to Single-Vision Spectacle Lenses or Placebo Based on the Network Meta-analysis

	Ineffective*	Weak†	Moderate‡	Strong§
Atropine				
High dose (1% or 0.5%)				R: **0.68 (0.52-0.84)** AL: **−0.21 (−0.28 to −0.16)**
Moderate dose (0.1%)				R: **0.53 (0.28−0.77)** AL: **−0.21 (−0.32 to −0.12)**
Low dose (0.01%)			AL: **−0.15 (−0.25 to −0.05)**	R: **0.53 (0.21−0.85)**
Pirenzepine		AL: **−0.09 (−0.17 to −0.01)**	R: **0.29 (0.05−0.52)**	
PDMCLs		R: 0.21 (−0.07 to 0.48)	AL: **−0.11 (−0.20 to −0.03)**	
Orthokeratology			AL: **−0.15 (−0.22 to −0.08)**	
PBSLs		AL: −0.08 (−0.15 to 0.00)	R: 0.25 (−0.03 to 0.54)	
Cyclopentolate			R: 0.33 (−0.02 to 0.67)	
PASLs		R: **0.14 (0.02−0.26)** AL: **−0.04 (−0.09 to −0.01)**		
BSLs		R: 0.09 (−0.07 to 0.25) AL: −0.06 (−0.13 to 0.00)		
PDMSLs		R: 0.12 (−0.24 to 0.47) AL: −0.05 (−0.15 to 0.05)		
MOA		R: 0.14 (−0.17 to 0.46)		
RGPCLs	AL: 0.02 (−0.05 to 0.10)	R: 0.04 (−0.21 to 0.29)		
Timolol	R: −0.02 (−0.31 to 0.27)			
SCLs	R: −0.09 (−0.29 to 0.10) AL: 0.01 (−0.06 to 0.07)			
USVSLs	R: −0.11 (−0.35 to 0.13) AL: 0.03 (−0.06 to 0.11)			

AL = axial length change; BSL = bifocal spectacle lens; D = diopter; MOA = more outdoor activities (14-15 hrs/wk); PASL = progressive addition spectacle lens; PBSL = prismatic bifocal spectacle lens; PDMCL = peripheral defocus modifying contact lens; PDMSL = peripheral defocus modifying spectacle lens; R = refraction change; RGPCL = rigid gas-permeable contact lens; SCL = soft contact lens; USVSL = undercorrected single vision spectacle lens.

From Huang J, Wen D, Wang Q, et al. Efficacy comparison of 16 interventions for myopia control in children: a network meta-analysis. *Ophthalmology*. 2016;123(4):697−708. Copyright © 2016 American Academy of Ophthalmology. Reprinted with permission. Boldface data indicate statistically significant effects ($P < 0.05$). A 0.18-mm AL change is estimated to produce a 0.50-D change in refraction.

*R: ≤0 D/yr; AL: ≥0 mm/yr.

†R: 0−0.25 D/yr; AL: 0 to −0.09 mm/yr.

‡R: 0.25−0.50 D/yr; AL: −0.09 to −0.18 mm/yr.

§R: ≥0.50 D/yr; AL: ≤−0.18 mm/yr.

interventions may interact when used concurrently. Additionally, patient adherence tends to be lower in actual practice compared with the idealized environment of clinical trials. Wu et al[83] demonstrated the efficacy and safety of atropine use over an average of 4.5 years. Atropine 0.01% eyedrops were effective in slowing myopia progression with fewer visual side effects compared with higher concentrations of atropine over a 5-year period.[84] Both OOK and atropine eyedrops (all concentrations) are currently used off-label in the United States for myopia control, and atropine requires a compounding pharmacy for lower concentrations. Kinoshita et al[87] found that combination therapy of OOK with 0.01% atropine outperformed OOK alone in Japanese children over the course of 1 year, which may indicate an additive benefit to combining current treatment methods.

Among modifiable risk factors, the most intensive focus has been given to increasing outdoor time to mitigate the risk of myopia onset. Studies have found an inverse relationship between time spent outdoors and the risk of pediatric myopia onset.[14,88−93] The cluster randomized trial of children in Guangzhou, China, by He et al[94] found that the 3-year cumulative incidence of myopia was lower in children who had 40 minutes of outdoor time added to their school schedules (30.4% vs. 39.5%; $P < 0.001$), although the difference in axial length elongation did not reach statistical significance. The children were also encouraged to spend more time outdoors outside of school. The meta-analysis by Sherwin et al[95] demonstrated that each additional hour spent outdoors per week was associated with a 2% reduction in the odds of childhood myopia developing. Despite the more established benefit in delaying the onset of myopia, the value of outdoor time in preventing myopic progression remains controversial, with most studies not finding a protective benefit. The meta-analysis of Xiong et al[96] failed to show any beneficial effect for outdoor time in reducing myopic progression, although Wu et al's[97] more recent randomized interventional controlled trial found that outdoor time had a protective effect against both myopia onset and myopia progression. Children in Boston experienced less myopic progression during the summer months, presumably as a result of spending less time in school and more time outdoors.[98] Furthermore, the findings of Wu et al suggest that high levels of sunlight exposure may not be necessary to achieve a therapeutic benefit: children's risk can be reduced with brief periods of high light intensity or extended periods of less intense light exposure.[99] Further

global studies are necessary to quantify the relationship between outdoor time and myopia, especially outside of East Asia. In summary, although minimal evidence supports the protective role of outdoor time in slowing myopia progression, strong evidence supports that outdoor time delays or prevents the onset of myopia, which could ultimately affect the amount of myopia exhibited in adulthood. Nevertheless, further studies are needed to quantify the ideal type, amount, and duration of exposure.

Conclusions

Myopia is a growing public health problem that carries significant visual morbidity on an individual- and population-based level. The growth in myopia prevalence, especially in East Asia, paired with the projected international growth in myopia prevalence and its secondary complications, are a cause for alarm. It is necessary to prioritize the development of effective interventions to stem the tide of the myopia epidemic. Creative and multidisciplinary problem solving that leverages the collaboration and expertise of eye care professionals, governmental agencies, school authorities, industry, family physicians, and pediatricians is necessary to address an international challenge of this magnitude.

In summary, the Academy's proposed role will encompass the following next steps, which will need to be tempered by the urgency and resources needed to address the global coronavirus disease 2019 pandemic. The Appendix (available at www.aaojournal.org) outlines further public health approaches as well as the proposed role of the Academy in dealing with the myopic epidemic.

Education

The Academy will seek to educate ophthalmologists, optometrists, the health care community, and public policy makers about the public health burden imposed by myopia. Educational resources for clinicians, nonclinical entities (e.g., governmental and school agencies), including the general public, and patients and their parents will be valuable to promote the importance of myopia as a public health problem and the value of slowing myopic progression. The Academy will serve as a resource for clinicians and organizations globally. The Academy will also strive to facilitate collaborative relationships among stakeholders for identifying novel approaches to myopia management and effective public health interventions and to advance the standardization of terminology to enhance the reporting of research findings.

Advocacy

The Academy will advocate in the United States and internationally to promote myopia as an important public health concern. This will involve collaboration with supranational organizations and regional public health agencies. The coronavirus disease 2019 pandemic will be a primary focus of public health organizations for the foreseeable future, and it is vital to ensure that the importance of myopia control, which requires a long-term perspective, remains a priority and is not overlooked. The Academy will advocate for appropriate patient access to methods to control myopia progression (e.g., effective pharmaceuticals and devices through appropriate regulatory approval processes and third-party payer policies). The Academy will also advocate for appropriate reimbursement for methods to slow myopia progression.

Research

The Academy will seek to foster collaboration among researchers, health care organizations, and industry internationally to develop novel interventions for myopia control. The Academy will seek avenues to promote multicenter randomized controlled trials of medical and public health interventions. The Academy will also perform big data analyses from registries (e.g., the Intelligent Research in Sight Registry) and will encourage observational studies to identify risk factors for the progression of myopia. In addition, the Academy will seek to support strengthening the regulatory science for evaluating drugs and devices intended to slow myopia progression.

Public Health

The Academy will aid the development of public health initiatives to prevent the onset and slow the progression of myopia. The Academy will collaborate with other leading public health entities to design and implement these myopia control initiatives. The Academy will additionally promote activities with parents and educational authorities to create school-based programs that incorporate and maintain educational standards while leveraging the benefit of increased outdoor time. The Academy's leadership and staff will work with pediatric and family physician organizations to communicate the value of outdoor time for children and encourage the screening and early diagnosis of children with myopia to maximize the benefit of myopia control interventions.

Footnotes and Disclosures

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[1] Department of Ophthalmology, Southern California Kaiser Permanente, Baldwin Park, California.

[2] Department of Research and Evaluation, Southern California Permanente Medical Group, Pasadena, California.

[3] Department of Ophthalmology, University of California, San Francisco, San Francisco, California.

[4] American Academy of Ophthalmology, San Francisco, California.

[5] Eye and Retina Surgeons, Singapore, Republic of Singapore.

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*A description of the Task Force membership and organizations involved is available online in the Appendix (www.aaojournal.org).

The Task Force on Myopia: Marcus Ang, MD, PhD (Singapore National Eye Centre, and DUKE-NUS Graduate Medical School, Singapore, Republic of Singapore); Susan Chiarito, MD (Mission Primary Care Clinic, Vicksburg, Mississippi); Susan A. Cotter, OD, MS (Marshall B. Ketchum University, Southern California College of Optometry, Anaheim, California); Angela Maria Fernandez, MD (Department of Ophthalmology, Central Military Hospital, Bogata, Colombia); Andrzej Grzybowski, MD, PhD (Department of Ophthalmology, University of Warmia and Mazury, Olsztyn, Poland); Mingguang He, MD, PhD (Centre for Eye Research, University of Melbourne, East Melbourne, Australia); Deborah S. Jacobs, MD (Massachusetts Eye and Ear Infirmary, Boston, Massachusetts); Jost B. Jonas, MD (Department of Ophthalmology, Ruprecht-Karls-University, Heidelberg, Germany); Alex Kemper, MD, MPH (Primary Care Pediatrics, Nationwide Children's Hospital, and The Ohio State University College of Medicine, Columbus, Ohio); Katherine A. Lee, MD, PhD (St. Luke's Children's Ophthalmology, St. Luke's Health System, Boise, Idaho); Andrea Delia Molinari, MD (Hospital Metropolitano, Quito, Ecuador); Ian Morgan, PhD (Research School of Biology, Australian National University, Canberra, Australia); Kyoko Ohno-Matsui, MD (Department of Ophthalmology, Tokyo Medical and Dental University, Tokyo, Japan); Michael X. Repka, MD, MBA (Wilmer Eye Institute, Johns Hopkins University, Baltimore, Maryland); Sarwat Salim, MD (Department of Ophthalmology, Tufts University School of Medicine, Boston, Massachusetts); Pei-Chang Wu, MD, PhD (Department of Ophthalmology, Kaohsiung Chang Gung Memorial Hospital, Kaohsiung City, Taiwan; Chang Gung University, Taoyuan City, Taiwan; and Taiwan Ministry of Health and Welfare, K-12 Education Administration in Ministry of Education, Taichung City, Taiwan); Ke Yao, MD (Eye Institute of Zhejiang University, Hangzhou, China); and Karla Zadnik, OD, PhD (The Ohio State University College of Optometry, Columbus, Ohio).

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Author Contributions:

Conception and design: Modjtahedi, Abbott, Fong, Lum, Tan, Ang, Chiarito, Cotter, Fernandez, Grzybowski, He, Jacobs, Jonas, Kemper, Lee, Molinari, Morgan, Ohno-Matsui, Repka, Salim, Wu, Yao, Zadnik

Analysis and interpretation: Modjtahedi, Abbott, Fong, Lum, Tan, Ang, Chiarito, Cotter, Fernandez, Grzybowski, He, Jacobs, Jonas, Kemper, Lee, Molinari, Morgan, Ohno-Matsui, Repka, Salim, Wu, Yao, Zadnik

Data collection: Modjtahedi, Abbott, Fong, Lum, Tan, Ang, Chiarito, Cotter, Fernandez, Grzybowski, He, Jacobs, Jonas, Kemper, Lee, Molinari, Morgan, Ohno-Matsui, Repka, Salim, Wu, Yao, Zadnik

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Overall responsibility: Modjtahedi, Abbott, Fong, Lum, Tan, Ang, Chiarito, Cotter, Fernandez, Grzybowski, He, Jacobs, Jonas, Kemper, Lee, Molinari, Morgan, Ohno-Matsui, Repka, Salim, Wu, Yao, Zadnik

Abbreviations and Acronyms:
AAO = American Academy of Ophthalmology; **CI** = confidence interval; **D** = diopter; **NHANES** = National Health and Nutrition Examination Survey; **OOK** = overnight orthokeratology.

Key words:
myopia, orthokeratology, public health, visual impairment.

Correspondence:
Flora Lum, MD, Vice President, Quality and Data Science, American Academy of Ophthalmology, 655 Beach Street, San Francisco, CA 94109. E-mail: flum@aao.org.

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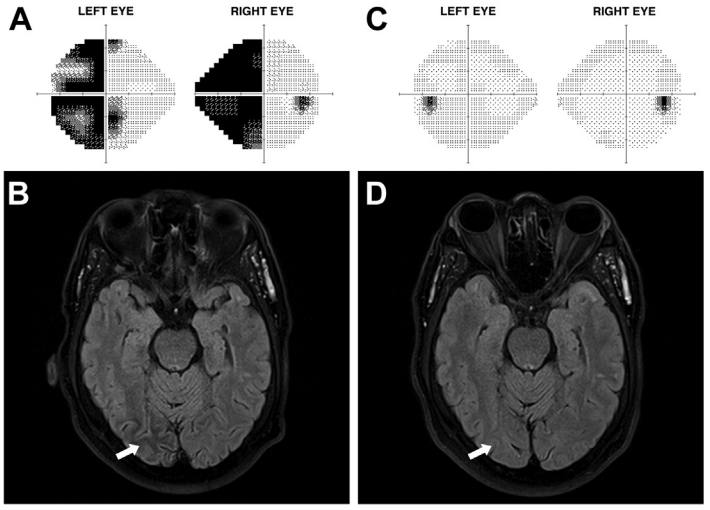
Pictures & Perspectives



Reversible Homonymous Hemianopia in a Newly Diagnosed Diabetic Man

A 53-year-old healthy man presented with acute-onset left homonymous hemianopia (HH) suggestive of a right occipital lobe stroke. Serum glucose was severely elevated (999 mg/dl, normal 64–138), consistent with hyperosmolar hyperglycemic state (HHS). Perimetry revealed left HH (Humphrey field analyzer, Fig **A**). Magnetic resonance imaging (MRI) demonstrated right occipital lobe subcortical T2 hypointensity, without diffusion restriction (Fig **B**). This unique pattern is inconsistent with ischemic stroke and has been described in HHS, possibly secondary to hyperglycemia-induced cellular metabolic dysfunction or focal seizure activity. At 1 month, the perimetry and MRI anomalies normalized with the treatment of diabetes (Fig **C** and **D**) (Magnified version of Fig **A–D** is available online at www.aaojournal.org).

Fares Antaki, MD, CM[1,2]
Ahmad Nehme, MD[3]
Kinda Najem, MD[1,2]

[1]Department of Ophthalmology, Université de Montréal, Montreal, Canada; [2]Centre Universitaire d'Ophtalmologie (CUO), Hôpital Maisonneuve-Rosemont, CIUSSS de l'Est-de-l'Île-de-Montréal, Montreal, Quebec, Canada; [3]Department of Neurosciences, Université de Montréal, Montreal, Canada