Public Health Burden and Potential Interventions for Myopia

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Myopia is the most common ocular abnormality in the world.[1,2] Its growing prevalence has resulted in it reaching near ubiquitous status in many East Asian communities, affecting 80% to 90% of young adults in many communities.[3–5] Approximately one third of adult Americans and Europeans are myopic.[6,7] A limitation of both of these estimates is that they used noncycloplegic refractions, which may have overestimated myopia in younger patients because of accommodation.[6,7] The estimated prevalence of myopia (≤−0.75 diopters [D]) among Europeans aged 50 to 54 years is 33.6%, with 2.6% of those in this age group being highly myopic (≤−6 D).[7] Vitale et al[6] estimated the prevalence of myopia (defined as ≤−0.5 D) using the National Health and Nutrition Examination Survey (NHANES) as 50.2% in individuals aged 20 to 39 years and 50.1% in individuals aged 40 to 59 years. The prevalence of severe myopia (≤−5 D) was 7.4% and 7.8% in these age groups, respectively.[6] In an effort to examine trends in myopia prevalence, Vitale et al[8] applied the definition of myopia from the 1971−1972 NHANES to their more contemporary cohort[6] to make these groups comparable. Although these older criteria likely overestimated the prevalence of myopia, the authors found that myopia had become more common among 12- to 54-year-old individuals over the 30-year period between NHANES surveys (25.0% vs. 41.6%, $P < 0.001$).[8]

Despite the frequency, increasing prevalence, public health burden, and financial costs of myopia, this problem remains largely underappreciated by the ophthalmic community.

An estimated 1.406 billion people in the world are myopic (22.9% of the population), and 163 million have high myopia (2.7% of the population).[2] Holden et al[2] estimated that the number of individuals as well as the prevalence of both myopia and high myopia will increase by 2050 to 4.758 billion individuals (49.8% of the world population) and 938 million people (9.8% of the world population), respectively. These crude approximations relied on several assumptions, including extrapolating the rates of myopia to large regions on the basis of a single country or limited data and did not account for how changes to educational systems and technology may influence trends. Additionally, the projections of future myopic disease burden relied on applying the standard increase in rate seen elsewhere to often inadequate regional data. The reliance on several significant assumptions means these results should be considered hypothetical. Within the United States, visual impairment among preschool children is projected to increase by 26% in 2060, with 69% of cases being from simple uncorrected refractive error.[9] The ability to reliably estimate visual impairment in preschool children is limited, and these estimates were derived by combining data from 3 different sources, which can lead to inaccuracies. Despite the limitations of these projections, the increasing prevalence of myopia is well established in several populations (especially in East Asia),[5,10] and these figures should provide justifiable concern to ophthalmologists even if the exact estimates are imperfect.

Glasses, contact lenses, and refractive surgery can address refractive error; however, myopic patients, especially those with high myopia, are at an increased risk of a host of secondary sequelae, including retinal detachment, glaucoma, cataract, choroidal neovascularization, optic neuropathy, staphyloma, and myopic macular degeneration. Uncorrectable visual impairment is seen in 4% of 75-year-olds with myopia and 39% with high myopia. Cross-sectional data from The Netherlands were used by Tideman et al[11] to project that uncorrectable visual impairment will increase 7- to 13-fold by 2055 in high-risk areas, although the accuracy of this estimate is complicated by the combined use of European data with Asian prevalence studies to make projections on Asian communities. There is also tremendous economic impact with a loss in global gross domestic product from uncorrected refractive error being estimated to be $202 billion annually.[12]

Efforts to reduce the prevalence, progression, and severity of myopia could have a profound public health impact, especially in East Asia. Despite the frequency, increasing prevalence, public health burden, and financial costs of myopia, this problem remains largely underappreciated by the ophthalmic community. The focus of intervention has been correcting refractive error, which carries financial incentive, and not addressing the underlying ocular pathology. Several strategies have been used to control myopia,[13] of which orthokeratology,[14–16] low-dose atropine,[17,18] and outdoor activity[19–23] have received the most attention. More recent attention has been given to specialized contact and spectacle lenses, including the Bifocal Lenses in Nearsighted Kids trial which is examining whether soft bifocal contact lenses can slow myopia progression. All the methods to try to control myopia require greater long-term follow-up to fully ascertain their potential benefit.

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There is compelling evidence that orthokeratology slows the progression of myopia.[13-16] Nonetheless, orthokeratology requires high levels of patient compliance and carries considerable expense. Although rare, the risk of sight-threatening complications (especially infectious keratitis) has also discouraged some from orthokeratology. Additionally, the sustainability of orthokeratology's effect remains unclear because studies examining long-term refraction after cessation are lacking. Orthokeratology has never gained widespread support or enthusiasm in the ophthalmic community and has traditionally been pursued by optometrists.

Although early studies suggested high-dose (1%) atropine might slow myopia progression, this failed to gain wide acceptance because of its secondary effects, particularly photophobia, glare, and difficulties with near acuity. Emerging evidence suggests that low-dose atropine may provide significant protection with fewer undesirable side effects, potentially at doses as low as 0.01%.[17,18] Huang et al[13] compared 16 different interventions for myopia control and found that atropine was superior to all others. The longevity of atropine's purported effect remains unclear and under study; however, Wu et al[24] demonstrated that low-dose atropine was well tolerated and resulted in less myopia progression compared with controls over a mean of 4.5 years. Higher doses of atropine have a greater effect on myopia progression but also a larger rebound effect after cessation, whereas patients receiving a low dose (0.01%) respond best to reinitiation of therapy.[18] When combining the treatment and washout phase of clinical studies, children receiving low-dose atropine (0.01%) had the least myopic progression.[18] Further studies are necessary to determine the ideal duration of treatment and how to best cease, or potentially titrate, atropine to reduce this refractive regression.[18] It remains to be seen whether prolonged use (especially past the formative growth years) may mitigate this rebound effect.

Greater time spent outdoors and illiteracy have long been associated with a lower incidence of myopia.[19-23] The exact mechanism responsible for this effect has been debated but is likely secondary to light stimulation of retinal dopamine, which discourages axial growth.[25] There is strong evidence that increased outdoor time is associated with lower rates of myopia.[19-23,26] The evidence that outdoor time can influence progression in myopic eyes is less impressive with a recent meta-analysis failing to find such an effect[26]; however, Gwiazda et al[27] did demonstrate that myopic progression was slower in the summer months in Bostonian children, likely due to children spending less time in school and more time outdoors. Additionally, Wu et al[28] demonstrated that children in schools that were randomized to encourage outdoor time had less myopic shift, less axial elongation, and a lower risk of rapid myopia progression compared with controls for both myopes and nonmyopes. Definitively proving a causative link between outdoor activity and myopia will require additional randomized clinical trials. Nonetheless, emphasizing outdoor activities is inexpensive, potentially effective, and appealing in most instances because it dovetails with other efforts promoting exercise, fitness, reduced screen time, and weight control. Better data are needed to clarify the level of benefit, parameters of exposure, and duration of benefit to develop more concrete recommendations.

Other practical questions remain, such as what degree of myopia should trigger which intervention, for how long, and how early in life. The threshold for treatment may be lower than most clinicians might expect. Although many previously thought that low levels of myopia were harmless, more recent data have demonstrated that the risk of uncorrectable visual impairment increases in a stepwise manner, with even low levels of myopia being associated with uncorrectable visual impairment; thus, even small myopic errors cannot be considered entirely benign.[1,11,29] Myopic patients have a lifelong risk of vision-threatening secondary sequelae as mentioned previously. Confronting the myopia epidemic will take a 2-pronged approach that relies on both individualized patient care and broad population-based initiatives that seek to reduce the prevalence and severity of myopia. The greatest benefit is likely derived from preventing children from attaining high or pathologic myopia because the visual morbidity is particularly elevated in this subset of myopes. Arresting progression of myopia will require individualized patient care to identify and intervene in myopes at risk for significant progression. As a result, creating models to accurately stratify patient risk should be a significant focus for future research endeavors. In addition, delaying the onset of myopia may result in fewer patients reaching high myopia. A population-based approach that aims to reduce the prevalence of myopia based on broad initiatives is also necessary to address this public health epidemic. Some interventions, including increasing outdoor time, are better served in the prevention of myopia onset and can be instituted in large-scale programs such as at schools.

Clinicians should be mindful of the significant impact myopia has on individual patients and, increasingly, populations at large, as well as the evolving interventions available to combat this condition. Additional clinical trials are necessary to better refine our understanding of myopia and interventions to lower its prevalence and severity; however, definitive evidence may take more than 10 years to collect, during which time another generation of children will have developed irreversible myopia. In the interim, available interventions remain readily available and inexpensive, and some may recommend therapy while awaiting more definitive studies. There is little downside to advocating outside time. Although low-dose atropine's effect may be low to moderate, it also carries low risk. While population-based interventions remain in development, individual practitioners should remain mindful of this epidemic. Physicians have a responsibility to educate their patients on the importance of myopia and discuss possible interventions, including their limitations, to children and their families. It is essential for ophthalmologists to work with optometrists, who are frontline providers, to determine a collaborative framework and referral patterns to prevent myopic progression, educate patients on the risks of myopia, and proactively address associated pathology to serve the best interest of our patients. As our understanding evolves, the increasing use of data-rich and powerful electronic medical records can allow healthcare systems to leverage their analytic capacities to identify those patients who may benefit from early intervention. An epidemic of this proportion will require macroscopic thinking. As such, ophthalmologists will need to reach out and work with optometrists, pediatricians, and even school administrators to develop the best research, reach the broadest population, and achieve the greatest impact.

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Footnotes and Financial Disclosures

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