

Community Eye Health Journal



Although a simple pair of spectacles will correct visual loss, they cannot prevent the blinding consequences of high myopia. **CAMBODIA**
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Myopia: a serious condition that needs our attention



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Myopia is a growing epidemic that will affect half the global population by 2050, and its complications can cause irreversible visual loss.

People with myopia – or short-sightedness – are unable to see objects that are far away, but can see near objects clearly. This affects every aspect of their life, including education, employment and safety.

Over 2 billion people worldwide are estimated to have myopia, defined as ≤ -0.5 dioptres (D). Of these, around 10% have high myopia, defined as ≤ -5 D.^{1,2} People with high myopia are at increased risk of potentially blinding eye conditions such as macular degeneration, retinal detachment, open-angle glaucoma and cataract.

Myopia is already a major public health challenge. In 2015, an estimated 480 million people worldwide were considered blind or visually

impaired because they did not have access to spectacles,³ making myopia the leading cause of visual impairment and blindness worldwide.

By 2050,² myopia is expected to affect 5 billion people, which is half of the projected global population at that time. This will place an even greater burden on health services to provide spectacles and to prevent and manage the conditions associated with high myopia.

Uncorrected myopia, together with macular degeneration, were estimated to be responsible for a US \$250 billion loss in global productivity in 2015.⁴ As myopia becomes more common, this is set to rise.

Continues overleaf ➤





About this issue

Myopia, or shortsightedness, is a major public health problem in East Asia. As low- and middle-income countries become more urbanised, the myopia 'epidemic' is likely to spread. This issue looks at ways to prevent and manage myopia and minimise its impact.

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Making a difference

Meeting the need for myopia correction, and slowing down or reversing the global increase in myopia, requires that we address service delivery, access to affordable correction, health promotion, advocacy and policy change at both national and global level. Collaboration between government, civil society, researchers, innovators and the private sector – rather than competition – is essential. The International Myopia Institute (www.myopiainstitute.org) is one example of a collaboration that is bringing about consensus on key issues such as definitions, clinical guidelines, clinical trials, and how to involve industry. We need more coalitions around education, service delivery, health promotion, advocacy, and research. Coalitions and partnerships will allow us to scale up efforts and make the impact that is needed.

Governments must take the lead in addressing the increase in myopia. National policies must address child eye health specifically; e.g., by making eye examinations compulsory for children at school entry and making it easier to import (or manufacture) products and drugs that can help to control myopia progression. Healthy school initiatives should include spending time outdoors as this has been shown to delay the onset of myopia (which means that children would be less likely to develop high myopia). Schools provide an ideal point of contact between health and refractive error services for children and their parents; e.g., by hosting health promotion activities that encourage parents to take children for an eye examination and to get the appropriate correction for them.

The private sector must support all components of a comprehensive approach, be it service delivery, human resource development, advocacy, policy change, research or health promotion. Industry should drive the agenda to create advanced, yet affordable, myopia control products, whether contact lenses or spectacle lenses, and make them accessible for all.

Non-governmental organisations (NGOs) involved in eye health are key to supporting the comprehensive approach by prioritising advocacy and policy change.

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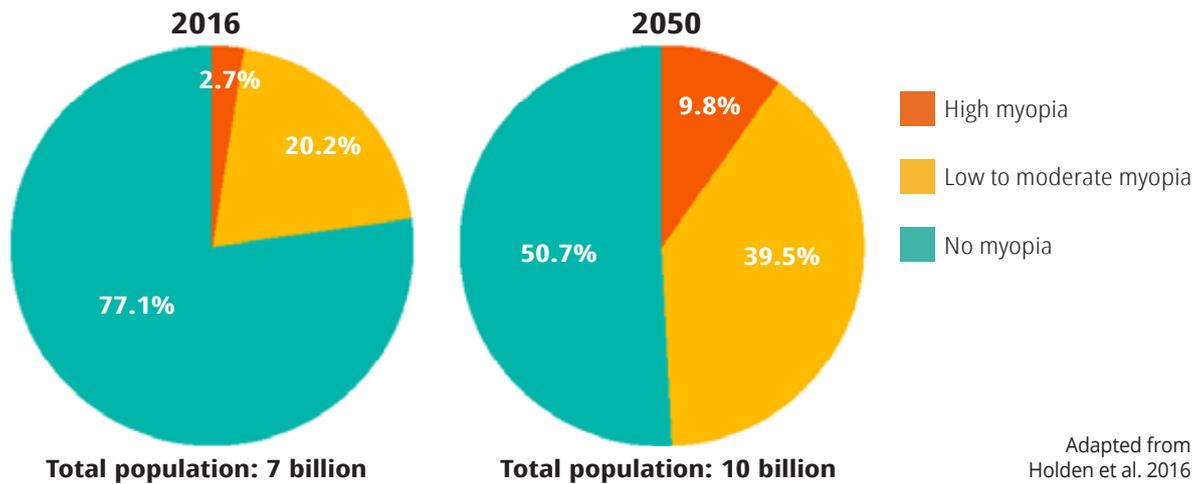
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Figure 1 Myopia and high myopia are rapidly increasing worldwide



NGOs must support the scaling up of services rather than see themselves as a replacement for either government or practitioners. They play a crucial role and can adopt a more active approach to influencing change. It is vital that myopia is included in World Health Organization, UNICEF, and other broader development agendas, as myopia has the potential to slow the education of our children and thus hamper efforts to achieve the United Nations' Sustainable Development Goals (www.un.org/sustainabledevelopment).

Optometrists, ophthalmologists and allied eye health professionals can all play a role in reducing the detrimental impact on quality of life due to myopia. Health promotion and education need to become a critical component of patient management. Eye care professionals will also need to support efforts to change government policy and use their connection in the community to become advocates for these changes. This issue discusses evidence for the myopia epidemic and the risks of high myopia along with the interventions available to reduce the risk of myopia and slow down its progression. While there are clinical and optical interventions to slow down the progression

of myopia, lifestyle and environmental changes (less near work and more time outside) are arguably of greater importance as it protects children against the onset of myopia. We have included practical tips on how to detect, refer, diagnose and manage myopia. A list of data that are required for monitoring myopia management are described to encourage clinicians to begin monitoring myopia progression in patients.

School eye health

School eye health programmes form an integral part of the global effort to address myopia. Read our 2017 issue on School Eye Health here: www.cehjournal.org/school-eye-health

BHARATH BALASUBRAMANIAN/APB STRONGER TOGETHER

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How myopia develops

Myopia is the result of abnormal elongation of the eye, so that light focuses in front of the retina rather than on its surface.

Myopia, otherwise known as near- or short-sightedness, is a common type of refractive error. In someone without a refractive error, light rays entering the eye meet and focus on the surface of the retina: the light-sensitive tissue at the back of the eye (Figure 1B).

In someone with myopia (Figure 1C), the light focuses at a point in front of the retina, which means that near objects are seen clearly, but objects further away are blurry. This can happen when the cornea is curved too much (is too 'steep') or the eye is too long.

Human babies are born long-sighted (hyperopic): distant objects are clear, but near objects are out of focus. This is because they have shorter eyes, so light focuses behind the retina instead of on it (Figure 1A). During the first few years of life, the eyes grow until they reach the expected length, when vision is normal (or emmetropic, see Figure 1B), without any refractive error. In most children, the eye remains like this for life. In some children, the eyes continue to grow and the child develops myopia (Figure 1C).

The eye tends to grow most rapidly during childhood and much slower in adolescence, when physical growth slows down. Children who developed myopia early (at 6–8 years of age) will have had more years during which their eyes can grow rapidly (and their myopia can progress) than those who develop myopia later, at age 12 onwards, when growth is slower.

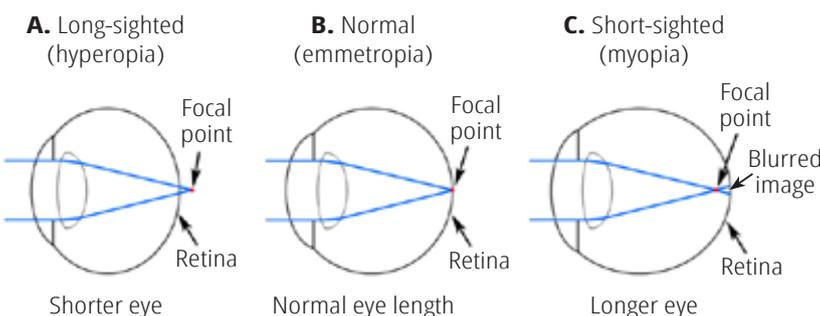


A baby's eyes will grow until they reach a normal length, with no refractive error. In children with myopia, the eye continues to grow. INDIA

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Figure 1 A and B. Normal development of the human eye: from hyperopia at birth (A) to emmetropia by early childhood (B). Some eyes grow longer and develop myopia (C).



Adapted from: Andrei V. Tkatchenko

Younger children are therefore at greater risk of eventually developing high myopia (≤ -5 dioptres (D) of correction). Conversely, postponing the onset of myopia, or slowing down the rate at which myopia progresses, will reduce the likelihood that a child will eventually develop high myopia.

High myopia is an irreversible and life-long condition. It can lead to physical changes in the eye, at which point it is referred to as pathologic myopia. In later life, people with high myopia are at greater risk of a range of potentially blinding eye conditions, including retinal detachment, glaucoma, cataract and macular degeneration.

A range of studies suggest that more time spent outdoors is effective at preventing or postponing the onset of myopia, although the precise mechanism for this is not fully understood. Time outdoors is not associated with a slowing of myopia progression in eyes that are already myopic,¹ but there are optical (p. 19) and pharmacological (p. 21) interventions that have been shown to make a difference.

What causes myopia?

Several different factors are thought to lead to abnormal elongation of the eyes. Genetic predisposition, environmental factors associated with urbanisation, increased near work and lack of time spent outdoors are all thought to be risk factors associated with myopia. When they act together, the risk increases.^{2,3}

Many genes are associated with myopia, each affecting a different part of the pathways which influence eye growth. Although a gene location for high myopia has been identified, there are no conclusions about a possible gene location for moderate levels of myopia. The relationship between genetic, optical and environmental factors is difficult to disentangle and remains unclear.



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High myopia and its risks

High myopia increases the risk of blinding eye conditions, so regular follow-up is essential.

High myopia is said to occur when a person's myopia progresses until they need -5 dioptres (D) or more of spherical correction,^{1,2} although the definitions used to grade myopia are variable.

The prevalence of myopia is increasing globally.³ It has been predicted that, by the year 2050, high myopia will affect 9.8% of the global population; a total of 938 million people.⁴ The highest prevalence of myopia is seen in younger adults, particularly in urbanised East and Southeast Asian countries.²

Even when appropriate refractive correction is provided, myopia continues to place an individual at an increased risk of sight-threatening diseases, including^{5,6}:

- Glaucoma (open-angle)
- Cataract (nuclear, cortical and posterior subcapsular)
- Retinal tears which may lead to a retinal detachment
- Myopic maculopathy or myopic macular degeneration

The incidence of these conditions is greatest in individuals with high myopia.

Glaucoma. A systematic review of the available evidence concluded that the risk of developing glaucoma was nearly 50% higher (or one and a half times as high) in individuals with moderate to high myopia, compared to those with low myopia (odds ratios [OR] of 2.5 and 1.7 respectively).⁷

Cataract. Higher rates of cataract surgery are seen in individuals with high myopia. Based on the available evidence, they are 17% more likely than those with moderate myopia to need cataract surgery (odds ratios of 3.4 and 2.9, respectively).⁸

Retinal detachment. The risk of developing a retinal detachment is five or six times greater in people with high myopia (OR >20) compared to those with low myopia (OR <4).⁹ People with high myopia have longer eyes (axial elongation), which means that the retina is more stretched and therefore prone to peripheral retinal tears. In addition, myopic eyes have a degenerate vitreous that is more likely to collapse and separate from the retina, also increasing the risk of retinal tears. High myopia can also cause central retinal degenerative changes such as posterior staphyloma, lacquer cracks and chorioretinal atrophy; these have been used to grade myopic maculopathy.¹⁰

Myopic macular degeneration (maculopathy). The risk of macular degeneration due to myopia rises sharply with age and increasing myopia.⁹ Myopic maculopathy may take the form of atrophic changes or be complicated by choroidal neovascular membrane



High myopia increases the risk of potentially blinding eye conditions. UK

(CNV) formation.¹⁰ Advanced myopic maculopathy causes loss of central vision and there is currently no treatment for the atrophic form. With the increasing prevalence of myopia, visual impairment caused by this condition will continue to rise.

Speaking to patients with myopia

It is important to make patients aware of these potentially sight-threatening conditions and that their risk appears to be proportionate their degree of myopia. Any sight loss should therefore prompt patients to seek a complete ophthalmic assessment.

Retinal detachment can affect any age group. Tell patients to contact an eye specialist immediately if they see flashing lights (usually seen in dim light in the temporal peripheral field) or floaters, or if they experience visual field loss. They must undergo an urgent dilated exam to exclude retinal tears and/or detachment.

Central visual loss as a result of advanced myopic macular degeneration can affect people of working age, so examine the macula at every visit. Individuals who develop CNV may be treated with intravitreal anti-VEGF therapies.¹¹ Refer those with central visual loss for low vision assessment and/or offer hand-held magnifiers.

Because the risk of open-angle glaucoma increases in individuals with high myopia, it is wise to assess intraocular pressure and optic disc appearance at every visit. Assess visual fields if possible.

Ophthalmic workers should acknowledge high myopia as a significant cause of visual impairment and a risk factor for a number of sight-threatening conditions.

Key messages

- High myopia is becoming more common
- Even if the refractive error is corrected, the eye is at risk of visual impairment, particularly if the myopia is ≤ -5 D
- Myopia increases the risk of open-angle glaucoma, retinal detachment, and myopic macular degeneration

High myopia

The definition of high myopia as ≤ -5 D was adopted as the World Health Organization (WHO) definition in 2015. A person who needs ≤ -5 D of correction has a visual acuity that is far worse than the threshold for blindness ($-3/6$ in the better eye).

Odds ratios (OR) are used to express relative risk in case-control studies such as those referred to in this article. In these studies, participants are grouped according to the outcome, e.g., whether they had cataract surgery or not, and then information is obtained about their exposure to a risk factor. In these studies, the risk factor is high myopia.

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The impact of uncorrected myopia on individuals and society

The rising epidemic of myopia will have far-reaching consequences for individuals and society unless we provide adequate treatment and care.



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Good distance vision is important for many activities; for example, recognising someone across the road, driving a vehicle and reading from a blackboard in school. The impact of uncorrected myopia varies depending on the age of the person affected. Those who develop high myopia, defined as ≤ -5 dioptres (D) are at increased risk of cataract, open-angle glaucoma, myopic macular degeneration and retinal detachment (p. 5), all of which has a personal and economic cost.



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The impact on children's education

Myopia usually starts to develop after the age of 10 years, but in East Asia it can start earlier. Uncorrected myopia can affect children's ability to learn in school and their quality of life.

An important benefit of providing school-aged children with spectacles is enhanced educational outcomes.

A randomised controlled trial among 20,000 children in 250 schools in Western China by Ma et al.¹ reported that mathematics test scores at the end of a school year had improved significantly among the 1,153 children who had failed visual acuity screening and were offered free spectacles; the difference was the equivalent of half a semester of additional learning.

An important finding in this study was that the beneficial effect of providing spectacles increased when there was a greater use of blackboards (rather than textbooks) for teaching in the classroom; this points to the impact of providing spectacles for myopia, as near-sighted children would be expected to benefit more from spectacles when trying to see a blackboard in the distance rather than a book that was close to them. Providing spectacles also exceeded the average educational impact observed in many other school-based health interventions in low- or middle-income countries, including dosing with iron to correct anaemia, giving vitamins and giving medications to eliminate parasites.¹

These results are consistent with studies of varying designs suggesting a causal association

“Myopia does not only affect educational outcomes; disadvantages arising from myopia also extend to quality of life and personal and psychological well-being.”



Spectacles improve academic performance, and may assist myopia control. PAKISTAN

between better visual acuity and children's academic performance. In a prospective cohort study, Jan et al.² have reported that Chinese children with better presenting vision at the beginning of the 7th grade had significantly better test scores at the end of the

9th grade (adjusted for baseline test performance). Additional studies are needed in school settings outside of China, and studies are also needed to determine whether provision of free spectacles can significantly improve other important indicators of children's academic success, such as remaining in school.

Although programmes of free spectacle delivery are shown to increase children's use of spectacles significantly,^{1,3} the impact has been limited by sub-optimal spectacle wearing, which may be 40% or lower.^{1,4} Effective methods to increase spectacle wear may vary from place to place, but are important to maximise the educational impact for children.

The personal impact of myopia

Myopia does not only affect education outcomes; disadvantages arising from myopia also extend to quality of life and personal and psychological well-being

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and development, particularly when individuals develop high myopia.

Adolescents with vision impairment reported statistically significantly lower quality of life, psychosocial functioning and school functioning scores.⁵ Myopia has also been demonstrated to significantly increase levels of anxiety among adolescents,⁶ whereas studies in children have identified links between having myopia and experiencing low self-esteem. Dias et al.⁷ reported that children who experience more visual symptoms (e.g., tired eyes or headaches) tend to evaluate themselves less favourably in terms of their physical appearance, school work, social activities, and behavioural conduct. This finding is similar to another study in which more severe myopia was associated with lower self-esteem.⁸

Adolescents and younger children can experience social pressures against spectacle wear and may avoid wearing the spectacles they have been prescribed. These pressures have been identified in children across a range of contexts; for instance, children reported being teased or discriminated against (or being afraid of this) in studies from Brazil,⁹ India,^{10,11} Tanzania¹² and Timor-Leste.¹³ Parents are also sensitive to social pressures and hesitate to obtain spectacles for their children due to the stigma associated with this.¹⁴

Studies from high-income countries have shown that adults with high myopia reported psychological, cosmetic, practical, and financial factors specifically related to myopia that affected their quality of life.¹⁵

The economic impact on society

In 2015, uncorrected myopia was estimated to have caused \$244 billion of potential lost productivity worldwide. Macular degeneration due to myopia was associated with another \$6 billion of potential productivity loss.¹⁶ The greatest absolute economic burden was experienced in Asia.

There are very few economic evaluations of myopia correction and no economic evaluation of myopia prevention. However, disability weights have been used to estimate potential productivity loss as a proportion of the gross domestic product (GDP per person).¹⁶ In 2012, Fricke et al. found that the global cost of establishing educational and refractive care facilities was a small fraction of the projected global lost productivity for all types of uncorrected refractive error.¹⁷ In Singapore, for example, the cost of providing myopia care for adults in 2009 was an average of US \$709 per person,¹⁸ which is less than 2% of the GDP per person at the time. By comparison, the disability weights associated with blindness due to uncorrected distance visual impairment (0.187) and moderate distance vision impairment (0.031)¹⁹ represent potential lost productivity of 18.7% of GDP per capita and 3.1% of GDP per capita per person with myopia. Spending less than 2% of GDP per capita to avoid a bigger loss in productivity makes economic sense.

Conclusion

The potential improvements in academic achievement for children who receive myopia correction, along with associated quality of life and psychosocial

functioning gains – together with the economic case for myopia treatment in terms of productivity – speak to the need for interventions. However, addressing parents' and children's concerns about wearing spectacles and making efforts to maximise spectacle wear are critical for realising the economic or academic benefits of correcting myopia.

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Myopia: a growing epidemic

Myopia is a serious and growing problem that will affect low- or middle-income countries as they become more urbanised – especially when educational demands increase.

Evidence from various countries, age groups, and ethnicities¹ indicates that myopia, defined as refractive error ≤ -0.50 D in the least myopic eye, currently affects approximately 28% of the global population.² In the highly developed urban areas of East and South East Asia, as many as 90% of school leavers have myopia.^{2,3} In Europe and North America, 30–50% of school leavers are affected and, in sub-Saharan Africa, myopia affects 5–15% of these children.^{2,4}

Uncorrected myopia is the leading cause of blindness worldwide. In 2015, there were 124 million people around the world with moderate or severe vision impairment (MSVI) or blindness due to uncorrected refractive error. The other leading causes were cataract (66 million people) age-related macular degeneration (10 million people), glaucoma (7 million), diabetic retinopathy (3 million) and other (or unidentified) causes (37 million).⁵

There are two main ways myopia can cause visual impairment. The first is via un- or under-corrected refractive error. Distance vision impairment can result when a person with myopia is unable to get appropriate spectacles or contact lenses or have them updated as needed. Second, increasing myopia is associated with increasing prevalence of visual impairment from complications that cause irreversible visual loss, including glaucoma and vitreo-retinal diseases such as myopic macular degeneration and retinal detachment.

Evidence consistently suggests that the global prevalence of myopia is increasing,² with the rate of increase being particularly alarming in many Asian countries.⁶ Holden et al. (2016) predicted that the global prevalence of myopia will rise from 28% (2 billion people) in 2010 to 50% (5 billion people) in 2050.² The same study predicted that the global prevalence of high myopia will rise from 4% (227 million people) in 2010 to 10% (938 million) in 2050.²

Environmental factors and lifestyle changes, such as increased time indoors (related to increased educational demands⁷), increased use of electronic



Children waiting for an eye examination. ZAMBIA

KAREN SPARROW, COURTESY OF IAPB

devices and decreased time spent outside are highly associated with the increased prevalence of myopia.³ There are also reports implicating factors such as town planning (the design of our built environment) and diet (higher saturated fat and cholesterol intake).⁸

Changing demographics

The groups of people affected by myopia (or the demographics of myopia) appears to be changing in two ways that are important in the link between myopia and visual impairment²:

- 1 As countries develop and people become more urbanised, the myopia epidemic will increasingly affect areas with fewer resources and with health systems that are less ready to deal with myopia and its complications.
- 2 Even though myopia will initially only affect children, the fact that it is a life-long condition means that it will 'spread' to all age groups over the next several decades.

People who live in a low-income setting will be less likely to have access to adequate optical correction and the health care systems needed to adequately manage the complications associated with myopia (p. 11).^{9,10}

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Can myopia be prevented?

Increasing children's outdoor time and reducing near work can delay the onset of myopia, which reduces the risk of high myopia and its complications.

Children who develop myopia at an early age have a greater risk of eventually developing high myopia (≤ -5 dioptres [D] of correction). High myopia increases the risk of retinal detachment, macular degeneration, open-angle glaucoma and cataract. One of the most cost effective ways to reduce this is to prevent or delay the onset of myopia.

The rapid rise in myopia prevalence in recent decades is likely due to environmental factors, such as living spaces (urban versus rural locations),^{1,2} indoor versus outdoor activity^{3,4} and seasonal variations in eye growth.⁵ However, it may be possible to modify these environmental factors in order to reduce or delay the onset of myopia. As early onset of myopia results in high levels of myopia, due to faster ocular growth and greater annual progression during the developmental years,⁶ intervention at an early age also appears to be critical.

What is the main cause?

Children who perform more near work are more likely to have myopia, and the odds of this increases with additional near work activities each week.⁷ Although the exact mechanism is unclear, researchers suggest that hyperopic defocus from accommodative impairment could be a factor.

Interestingly, studies have also found that more time outdoors delays myopia onset.⁸ Exposure during school recess to outdoor light (sunlight) totalling 11.2 hours per week⁹ or exposure to light in school hallways or under the trees for a longer duration (3.3 hours per day)¹⁰ has been effective at reducing myopia incidence. Similarly, previous data involving Caucasian and East Asian children growing up in Australia, Singapore and United States found a total of 10–14 hours per week of outdoor time was effective for delaying myopia onset.^{4,11} A recent longitudinal study conducted in Australia evaluated children's light exposure using a wearable measuring device; it observed slower eye growth in children exposed to more light each day.¹² The intensity of artificial indoor light is substantially less than outdoors,¹³ and it also consists of a different spectrum of frequencies. The levels of dopamine, which may play a role in inhibiting eye growth, have also been shown to increase with exposure to light.¹⁴

Evidence suggests that a multi-pronged approach with reduced near work (especially for young children), living spaces with more natural light as well as promoting time



Posters by the government of Singapore encourage children to spend more time outdoors. SINGAPORE

outdoors could be beneficial in delaying or preventing myopia onset. These strategies also have other health benefits, such as reduced risk of obesity and improved physical activity and mental health, so all children will benefit if these are implemented.

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Myopia in low-resource settings

Increasing levels of myopia will pose particular challenges in low- or middle-income countries. Preventing or delaying myopia onset is crucial.

Providing correction for myopia is a major challenge in low- and middle-income countries that have limited trained ophthalmic personnel and who are faced with other barriers; e.g., the cost of spectacles and misconceptions about spectacle wear. The challenge should not be underestimated: uncorrected refractive error is the single biggest cause of visual impairment and blindness worldwide.¹

A second challenge is dealing with the pathological consequences of high myopia, defined as ≤ -5 dioptres (D). Myopia imposes a greater risk of retinal detachment from an early age,² and signs of pathological myopia, such as myopic macular degeneration and staphyloma, can start to appear in young adults with high myopia and worsen with age. Myopic macular degeneration is the first or second cause of blindness already in East Asia.³ In addition, high myopia is the most common cause of choroidal neovascularisation in people under 50 years of age in high-income countries,⁴ and people with myopia are at greater risk of developing cataract and glaucoma.⁵ Many of these secondary conditions are clinically challenging.

As the prevalence of myopia has increased, early onset of myopia has become more common, allowing more time for progression to take place.⁶ Based on existing data, a child who first becomes myopic in mainland China at the age of 6–8 years is likely to develop high myopia. One who develops myopia at the age of 12–13 or later is unlikely to end up highly myopic. It is therefore very important to delay the onset of myopia and to control its progression.

Fortunately, we know how to do both. Increasing time spent outdoors during childhood delays the onset of myopia as demonstrated in randomised clinical trials,⁷⁻⁹ and as a system-wide programme in Taiwan. The aim should be to ensure that children in the primary school years get at least 2-3 hours a day outdoors, based on



Learning outdoors for all or part of the day protects children against the onset of myopia. The light under trees is bright enough to make a difference. ETHIOPIA

S. OGDEN / INTERNATIONAL COALITION FOR TRACHOMA CONTROL

epidemiological evidence⁶ and clinical trial results.⁷⁻⁹

There are several treatments that can control myopia by slowing down its progression.¹⁰ Daily low-dose atropine (p. 21) is reported to reduce progression by close to 60%, and executive bifocal spectacles with +1.5D near addition is reported to reduce progression by 50% (p. 19). In terms of cost, the use of low-dose atropine is likely to be preferred in low- or middle-income settings. These interventions, where available and affordable, could eliminate or drastically reduce the risk of developing high myopia/pathological myopia and the conditions associated with it (p. 5)

For progression control efforts to be effective, prompt detection and referral is essential (p. 15). Annual refraction and eye examination (p. 17) makes a lot of sense, at least until progression rates have slowed.

In countries already gripped by a myopia epidemic, putting these measures in place is urgent. In other countries, regular visual acuity screening for referral, as well as surveillance of trends, would also be useful. Increased time outdoors provides a simple, low-cost primary intervention that should be backed up with progression control, where possible. Where climate or pollution limits this possibility, innovative solutions such as bright classrooms, or bright desk lamps for home study, may be required.

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Advocacy to reduce the risk of myopia

Encouraging and supporting the changes needed to prevent or delay the onset of myopia is complex. Co-ordinated advocacy is key.

The evidence for a global rise in the prevalence of myopia paints a worrying picture for the eye health of future generations. Although the causes are not completely understood, it is clear that myopia development and progression is multifactorial, and that environmental, lifestyle, and genetic factors are involved.¹ The evidence is also clear that the myopia epidemic is real and that controlling it will require cross-sectoral efforts at collective and individual levels.

Although we have little ability to modify demographic risk factors such as ancestry, age and gender, it appears that myopia is also heavily influenced by modifiable risks such as near activity and outdoor time.

Modifying lifestyle factors, especially in young children, is likely to delay or prevent myopia onset. However, the influences on child behaviour are complex and vary with place and culture. Given these complexities, multi-dimensional approaches are needed to provide strategies that suit local situations and facilitate support from individuals, families, governments, health and educational bodies.

Advocacy to minimise the risk factors for myopia onset

Advocacy – practical engagement through positive action and communication with the people and organisations who can make these changes – is essential. The suggestions below can be delivered by eye care practitioners, health bodies, governments, schools, etc. to individuals, families, schools, communities in order to modify the three risk factors with potential to influence myopia onset: an over-emphasis on education in children younger than 12 years old, lack of time outdoors, and too much time on near activities.

Over-emphasis on education, particularly in children younger than 12 years of age

Advocacy aimed at:

- Encouraging balanced lifestyles for the purpose of eye health



Posters by the government of Singapore encourage children to spend more time outdoors and reduce their screen time. SINGAPORE

- Improving 'visual hygiene' (sensible working distances, regular breaks from near tasks, good illumination)
- Making the educational environment 'anti-myopic' (e.g. bright classrooms).

Lack of time outdoors

Advocacy aimed at:

- Encouraging balanced lifestyles for the purpose of eye health
- Town planning that encourages outdoor time
- Incorporation of outdoor time into education.

Too much time on near activities

Advocacy aimed at:

- Encouraging balanced lifestyles for the purpose of eye health
- Limiting screen time.

We are facing a global myopia epidemic which requires combined efforts of researchers, parents, teachers, communities and governments to work together to reduce this burden that will affect us all economically via lost productivity, and will impact individuals' quality of life.

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Preventing myopia in East Asia

Spending enough time outdoors can drastically reduce the risk that a child will develop myopia.

The prevalence of myopia among school-aged children has been increasing over several decades, reaching up to 80% among junior high school graduates in East Asian populations,¹ particularly in China's most developed cities, Hong Kong, Taiwan and in those of Chinese descent living in Singapore.

To cope with this epidemic, risk factors and effective methods of prevention must be identified. Although increasing educational pressures and near work time have been highlighted as important risk factors for the increasing prevalence of myopia,² it is unlikely that there will be a cultural shift in the focus on academic performance in these communities. Therefore, there is an urgent need to identify other modifiable risk factors for myopia.

Increased time spent outdoors was first proposed as a protective factor in a 3-year follow-up study³ and then reported in various studies, such as the Sydney Myopia Study,⁴ Orinda Study⁵ and a cohort study from Singapore.⁶ However, such reports can only prove association rather than a causal effect.

In 2009, a 3-year randomised trial in Guangzhou, China proved that an additional 40 minutes of outdoor activity at school reduced the 3-year cumulative incidence of myopia from 39.5% to 30.4%, a relative reduction of nearly 25%, among grade 1 primary school students.⁷ Another clinical trial in Taiwan suggested that 80 minutes of outdoor time per day could reduce the incidence by 50%.⁸ It is possible that outdoor intervention may have a dose-response preventative effect for myopia, though further studies are needed to substantiate this.⁸

A few approaches to maximise outdoor exposure have been suggested, given the fact that it is unlikely that class time will be reduced in the East Asian setting. One

Figure 1 A bright classroom designed to delay the onset of myopia



RONGBIAO HUANG



Outdoor activities help to delay the onset of myopia. CHINA

RONGBIAO HUANG

approach is to incorporate class time in an outdoor environment, while another is to lock classroom doors during break or play time (recess) which could add an additional 60 minutes of outdoor time.

Another approach is to increase in-classroom illumination during lessons. Our research group has proposed an innovative classroom design that incorporates a glass roof and walls in an attempt to maximise light intensity while students study indoors (Figure 1).⁹ We have also attempted to develop an LED lamp that resembles outdoor light intensity in the classroom. The efficacy of these two interventions are currently being investigated.

When school leaders or parents try to implement interventions that increase students' time spent outdoors, they must also consider protecting the students against sunburn or damage caused by ultraviolet radiation. A recent study in Taiwan suggests that a much lower illumination of 1,000–3,000 lux (equivalent to illumination levels under tree shade) is sufficient to generate a protective effect.¹⁰

Other interventions, such as targeting smart device screen time or eye exercises, are yet to be supported by scientific evidence.

China has recently proposed a country-wide myopia control strategy engaging both the education and health sectors, which involves government policy reform, involvement of schools and parents in myopia prevention, improved health services targeting myopia, and health promotion discouraging risky behaviours leading to myopia.¹¹

The impact of increasing outdoor time is far-reaching. A 25% reduction in incidence among primary school students would mean a significant delay in the onset of myopia, and this could reduce the prevalence of myopia and perhaps high myopia in the wider population. The challenge is how to translate these findings into an intervention that can be delivered during day-to-day school activities.

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How to detect myopia in the eye clinic

Ophthalmic nurses and other allied health personnel can detect myopia using a Snellen chart and a pinhole occluder.

Myopia is a refractive error that occurs when the eye is longer than normal or has a cornea which is too steep (p. 4). People with myopia, also known as short- or near-sightedness, can see near objects clearly, but objects further away appear blurred and out of focus. Normal vision can be restored by prescribing the correct spectacles or contact lenses.

Ideally, refractive errors in children (myopia, hypermetropia and/or astigmatism) should be detected in eye screening programmes in schools or in the community. In the absence of such programmes, adults and children will present at the clinic with a range of conditions.

It is therefore important to be aware of myopia and to look out for it when performing an eye examination.

About myopia

Myopia can be inherited, and there is also evidence that it is more likely to occur in communities where children spend less time outdoors and more time doing near work. It can be corrected using spectacles

or contact lenses of the correct power, expressed in dioptres (D). People who require ≤ -0.50 D of optical correction are considered as having myopia.

High myopia affects around 10% of people with myopia, and is defined by the World Health Organization as requiring ≤ -5 D of correction. People with high myopia are at greater risk of macular degeneration, retinal detachment, glaucoma and cataract. Of these, cataract is the only reversible condition: sight can be restored in a single, quick surgical procedure. Retinal

detachment can cause sudden visual loss and requires urgent surgical treatment to re-attach the retina; failure to do so can result in a complete loss of vision in that eye. Macular degeneration and glaucoma cause progressive visual loss that cannot be reversed, so early detection is essential as medication or surgery can, at best, slow down or halt their progression.

This article describes how to detect myopia and when to refer someone to the appropriate health professional for a comprehensive eye examination, refraction and spectacle prescription.

1 History, symptoms and signs

Indicators of myopia in children include:

- Poor distance vision
- Viewing objects from an unusually short distance
- Poor concentration in school
- Squinting or peering through narrowed eyes.



Testing visual acuity using a tumbling E chart. UGANDA

People with myopia may complain of:

- Blurred distance vision
- Frontal headaches.

Ask about the person's previous eye history, e.g. spectacles or lazy eye, and about family history, including myopia (due to the familial link), glaucoma, diabetes mellitus and hypertension. Floaters and flashes of light are associated with retinal detachment and requires urgent referral to an ophthalmologist. Double vision is associated with a range of conditions, including strabismus (lazy eye) and neurological disorders, and requires referral to a medical professional or ophthalmologist.

Ask about general health, medications, whether the person drives, and their hobbies.

End with the open-ended question: "Is there anything else that you feel I should know about your eyes or your health?" If you have been thorough in your questioning, the answer should be no, which can be recorded in the notes as NOC (no other comments).

2 Measure visual acuity

Visual acuity testing must form part of every eye examination. 'No refractive error' at this distance is deemed to be 6/6 or 20/20, even though there may be even smaller lines on the chart, such as 6/5 or 6/4.

Steps

- Use a Snellen chart, placed 6 metres (20 feet) away from the person.
- For younger children or those who cannot read, use a tumbling E or a tumbling C chart and ask them to point in the direction of the opening in each letter.
- Ensure there is good natural light or illumination on the chart, as Snellen charts are designed to test

“There is evidence that myopia is more likely to occur in communities where children spend less time outdoors and more time doing near work.”

central vision at high contrast.¹

- Explain the procedure to the person.
- Position the person, sitting or standing, at a distance of 6 metres (20 feet) from the chart.
- Clean and dry the occluder. If no plain occluder is available, use clean card or a tissue. Ask the patient to cover one eye but not to press on it.
- Test one eye at a time. Starting from the top of the chart, ask the person to read the letters (Snellen chart) or point in the direction of the open end of the letter (tumbling E or C chart). Position the chart at 3 metres (10 feet) if the person's vision is less than 6/60 and record as 3 metres instead of 6 (e.g. 3/60).
- Record the visual acuity (written as a fraction next to the smallest line the person can read). For example, if the person cannot read the bottom row (visual acuity of 6/6) but can read the next row of letters (6/9) then their visual acuity is 6/9.
- If the patient cannot see the letters on the 6/6 line, they may have a refractive error, such as myopia.

3 Perform a pinhole test

Pinhole testing is mainly used for adults and older children. Children under 7-8 years old would struggle to see with a single pinhole. Occluders with multiple pinholes may work better, but if these are unavailable, refer all children with VA of < 6/6 for refraction.

A pinhole occluder (an opaque disc with one or more small holes) is used to determine whether reduced vision is caused by refractive error. If this is the case, the pinhole will cause an improvement in visual acuity.

If the pinhole worsens vision, this can indicate macular disease, central lens opacities or other causes of reduced vision. If there is no change in visual acuity, this might be caused by amblyopia. Children and adults suspected of having these conditions must be referred.



HEKO PHILIPPIN

Steps

- Clean and dry the pinhole occluder.
- Ask the patient to cover one eye with the occluder and position the pinhole so they can see through it.
- Test one eye at a time by following the same procedure used to test visual acuity.

4 Should I refer?

If the person can read more letters with the pinhole than without, they are likely to have a refractive error, such as myopia. All patients (adults and children) whose acuity improves with a pinhole, and/or who present with symptoms consistent with a refractive error, should be referred for a full refraction and an eye health examination. Refer patients with signs or symptoms of eye disease for a comprehensive eye examination (including a slit lamp examination, if possible) if you are unable to carry one out yourself.

A pinhole occluder is an opaque disc with one or more small holes. In people with myopia, visual acuity increases with the use of a pinhole. TANZANIA

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Who is at risk of myopia?

By **Tim Fricke, Priya Morjaria** and **Padmaja Sankaridurg**

Ethnicity is a significant risk factor, with individuals from East and South East Asian countries at greater risk of developing myopia.¹ More importantly, myopia begins at an earlier age in these individuals, resulting in a greater number of years during which myopia can progress. This increases the risk that they will develop high myopia.²

Older children are more likely to develop myopia.³ However, annual progression is significantly greater in younger children.⁴ A 6-year old child with myopia will have significantly greater progression than, for example, a 10-year-old, placing them at greater risk of high myopia.

Parental myopia may also influence onset with those with both parents being myopic at greater risk of developing myopia.²

There is also a small difference in prevalence between males and females, with females at greater risk of myopia than males.⁵



JAYASHREE KUMAR

Girls are more likely than boys to develop myopia, although the difference is small. INDIA

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Practical tips for managing myopia

This article presents a summary of practical approaches to diagnosing myopia, myopia management (with particular attention to low resource settings), reviewing myopia progression, and collecting data for myopia management programmes.

Part 1 Diagnosing and prescribing for myopia

While myopia might be initially detected by a patient (e.g. reporting distance blur), or an adult observing behaviour changes in a child (e.g. squinting or viewing things closer than expected), myopia is generally diagnosed by an eye care professional.

Equipment

The minimum required equipment to diagnose myopia and assess progression includes:

- A high-contrast distance visual acuity (VA) chart (e.g., Snellen, logMAR, E, or LEA)
- A room or space where the viewing distance for VA is at least 3m/10ft. The chart should be well lit and calibrated for the working distance
- Occluder (ideally with pinhole occluder)
- Retinoscope
- Trial lens set (including Jackson Cross Cylinder) or phoropter

Equipment that could assist with myopia diagnosis, management and estimation of progression:

- Near VA chart
- Autorefractor
- Heterophoria measurement method (e.g., MIM card or Howell phoria card)
- Lens flippers (± 1.00 and ± 2.00 D)
- Prism bars
- Optical biometer for axial length measurement
- Cycloplegic eye drops (e.g., tropicamide, cyclopentolate or atropine).

Clinical techniques

To prescribe for myopia appropriately, the clinical techniques below are recommended as a minimum:

- Visual acuity (VA)
- Retinoscopy
- Subjective refraction
- Ocular health assessment.

The following clinical techniques are recommended and should be conducted where possible:

- Cycloplegic refraction / autorefraction
- Axial length measurement.

The binocular vision tests below can measure the effect of a myopia management strategy on the individual's binocular vision status and visual comfort. This will help you to determine the appropriateness of a myopia management strategy for that person.



Refraction is the first step. MEXICO

EDGARDO CONTRERAS, COURTESY OF IAPB

- **Monocular estimate method (MEM) retinoscopy.** An objective method to determine a child's accommodative (near focussing) status at near. Retinoscopy should be conducted with a near target.
- **Accommodative facility.** A subjective method to assess accommodation function (ability of eye to focus at near).
- **Subjective phorias.** A subjective method to determine whether the eyes prefer to converge in or diverge out, at distance and near.
- **Vergence reserves.** A subjective method that measures the eyes' ability to converge in and diverge out.
- **AC/A ratio.** Assesses the interaction between accommodation and convergence.

Cycloplegic refraction

An accurate refraction is very important in diagnosing myopia and monitoring myopia progression. Ideally, a child with myopia should undergo cycloplegic refraction at the initial presentation and then at least every 12 months. This allows the clinician to accurately determine the refractive error without the effect of an active accommodation system. However, if cycloplegic refraction is not possible, a careful subjective refraction must suffice.

Common agents used for cycloplegia include cyclopentolate (0.5% or 1%), tropicamide (0.5% or 1.0%) and atropine (1%). Studies have found tropicamide 1% to be effective in monitoring standard cases of myopia progression.^{1,2} Therefore, tropicamide 1% is worth considering for cycloplegic refraction as it reduces the duration of glare and near symptoms compared to other options.

If conducting cycloplegic refraction, inform patients that the eye drops may sting for a few seconds before instilling them into the eye. Advise that their vision may be blurred, especially at near, and they may be light sensitive for a few hours, so sunglasses should be worn if possible.

What should you prescribe?

Use the cycloplegic refraction results from retinoscopy or autorefraction as the starting point and then refine to achieve the best possible VA. If there is a large difference between the cycloplegia objective and subjective refraction, recheck your results.

Uncorrected astigmatism

In low-resource settings where sphero-cylindrical lenses are unavailable to correct astigmatism, spherical lenses might be prescribed to correct myopia. The level of blur is dependent on the amount and type of astigmatism and currently there is no evidence on the effect of uncorrected astigmatism on myopia progression.

Under-correction is ineffective

Studies show prescribing single vision lenses with under-correction (less minus) made no difference compared to full correction, and in some cases, it made the myopia progression worse.^{3,4} This suggests that if you are only able to prescribe single vision spectacles, full correction is recommended.

Part 2 Options for managing myopia

For children at risk of developing myopia, advise at least 90 minutes of outdoor time daily,⁵ and regular breaks from near work.

Myopia management interventions for children with progressive myopia can be divided into three categories (Table 1). These may not all be available in low- or middle-income countries. Each intervention is generally prescribed alone. However, you could consider combination treatment (for example, adding low-dose atropine to an optical treatment) if there is a high risk of fast progression or poor response to individual treatment. You can prescribe single vision lenses if you consider the patient's myopia to be stable, especially if the patient is an adult.

Table 1 Myopia management interventions

Pharmacological	Optical: spectacles	Optical: contact lenses
<ul style="list-style-type: none">Low-dose (0.01%) atropine (might require a specialist compounding pharmacy)	<ul style="list-style-type: none">Executive bifocalsProgressive addition lenses	<ul style="list-style-type: none">Dual-focus and multifocal centre-distance contact lensesOrthokeratology

Choosing a myopia management strategy

Consider:

- The options are available in your setting
- Their effectiveness
- Patient suitability
- Patient and carer preference

Using your clinical judgement, decide which of the available options is most appropriate for your patient. If you are unable to prescribe that option, refer to a colleague who has experience with, and access to, that intervention.

What next?

Review periods

Review every 6 months. More frequent reviews may be required for patients when first introduced to each treatment strategy. Ongoing follow-up should be based on the patient's progress, treatment modality and performance.

What is fast progression?

Fast progression is progression of myopia of 1.00 D or more, per year.⁶ Younger children with myopia are more likely to progress faster than older children.⁷

How to estimate progression

You can estimate progression by comparing the difference in myopia before and after using a myopia management strategy. Ideally, you will be comparing cycloplegic refractions over at least 12 months. Table 2 is an example of estimating the rate and reduction of myopia progression:

Table 2 Recording and estimating the rate of progression: an example

Examination date	Age	Refraction
3 years ago	7	R -1.00 D L -0.75 D
2 years ago (started myopia management)	8	R -2.00 D L -1.75 D
Today	10	R -3.00 D L -3.00 D

- Prior to using myopia management, this patient had progressed -1.00 D in one year.
- With myopia management, they then progressed to R (right eye) -1.00 D and L (left eye) -1.25 D over 2 years, which is -0.50 D and -0.62 D per year, respectively.
- This is an approximate reduction of 50% in the right eye and 38% in the left eye.

Estimating progression might be difficult for patients prescribed orthokeratology, and measuring axial length might assist in these cases. However, you need to be aware that axial length also increases with age in children with emmetropia (normal eye length).⁸

Data collection for myopia management

Record keeping is important to monitor a child's risk of myopia onset, progression, and their response to treatment. This information can also assist in developing a database for planning programmes.

- The child's age of onset of myopia (at -0.50 D in either eye) from a cycloplegic refraction
- Ethnicity
- Family history of myopia
- Number of hours or minutes spent outdoors each day
- Number of hours or minutes spent on near work
- The type(s) of myopia management prescribed
- When the myopia management was initiated/ceased
- The amount of myopia (i.e. prescription) at each visit, at least annually, with cycloplegia
- Axial length (where possible).

Summary: managing myopia in low- or middle-income countries

- It is important that progressive myopia is diagnosed and managed appropriately.
- Know which myopia management strategies are available in your setting (such as executive or large segment bifocal spectacles, multifocal contact lenses, orthokeratology and low-dose atropine).
- Consider which myopia management strategy would be most appropriate for your patient.
- If that option is within your scope of practice, prescribe it. If not, refer your patient to a colleague who can prescribe it.
- Compare the annual rate of progression with and without myopia management using subjective refraction, ideally with cycloplegia.

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Optical interventions to slow the progression of myopia

Bifocal spectacles, progressive addition spectacles, dual focus contact lenses and orthokeratology each appear to reduce myopia progression.

People with myopia need vision correction (single vision glasses or contact lenses) to see objects that are far away. If their amount of myopia is increasing over time, there is a range of options to slow down the progression of myopia. This article will review the optical options that may be available where you work.



Spectacles improve academic performance and may assist in myopia control. PAKISTAN

Myopia management is a challenge, because:

- We have an incomplete understanding of what causes myopia to develop and progress.
- Myopia usually starts early in life and people have to live with it for a long time.
- Myopia can progress over many years or even decades.

Eye care practitioners should stay up to date with the latest available evidence and involve patients and their families in deciding what treatment is best for them. Explain that current methods can slow down the progression of myopia, not stop or reverse it.

Recommended interventions

Progressive addition lens spectacles

Progressive addition lens (PAL, or multi-focal) spectacles provide distance correction and a near addition without a visible line in the lenses, meaning they can correct myopia and reduce accommodative strain in a cosmetically appealing form. Practitioners who thought accommodative strain was the main cause of myopia progression expected that PALs would reduce progression; however, research results have been disappointing.

PALs have been assessed in well-sized, randomised (between PALs and single vision spectacles), double masked, multi-centre trials with robust testing procedures.¹ The studies used +2D near additions over each participant's distance refraction and monitored progression over 3 years.¹ Findings included:

- Lower compliance and higher drop out in the PAL

spectacles group compared to the single vision spectacles group, suggesting that some children did not like wearing the PALs.

- Across all participants, there was statistically significantly slower myopia progression in the PAL group in the first year, followed by equivalent progression between PAL and single vision spectacles.
- Across a subset of participants (children with high accommodative lag and near esophoria), there was an ongoing, cumulative, statistically significant reduction (24% on average) in myopia progression in the PAL spectacles group compared to single vision spectacles group.¹

Bifocal spectacles

Similar to PALs, bifocal spectacles provide a distance correction and a near addition, but with a visible line in the lenses, meaning bifocals are generally considered less cosmetically appealing. The near section of bifocal lenses can have different shapes (e.g., round- or flat-topped) and widths (e.g., 28 mm, 35 mm or executive/full width). If reduced accommodation strain is responsible for the small but significant reduction in myopia progression seen in specific children wearing PAL spectacles, results should be similar with any bifocal spectacles. However, myopia progression results may be different between PALs and various bifocal options if some other factor (e.g. dioptric demand across the visual field or peripheral focus) is more important in optically-mediated myopia control.

A randomised, controlled, but unmasked study compared myopia progression in Chinese Canadian children wearing executive bifocal spectacles compared

JAMSHYD MASOOD, COURTESY OF BRIEN HOLDEN VISION INSTITUTE

to single vision spectacles. Myopic refractive error and axial length both progressed significantly slower in children wearing the executive bifocals: around 50% less than single vision spectacles. The reduced progression appeared ongoing and cumulative over 3 years, and were independent of binocular vision profile.²

On face value, improved myopia control in executive bifocals compared to PALs suggests that progression is determined more by dioptric demand across the visual field and/or peripheral focus, than by accommodative strain. However, design weaknesses in the bifocal study mean it would be useful to see the comparison replicated in a masked, multi-centre trial without ethnicity-specific selection.

Dual-focus and multifocal soft contact lenses

Specifically designed soft contact lenses (e.g., dual-focus and centre-distance multifocal) provide a pattern of focus/defocus that animal models suggest will reduce myopia progression.³ The exact pattern of focus/defocus varies between lens types and manufacturers, but the centre of the lenses generally corrects the myopia permitting clear distance vision, while myopic blur is provided in the periphery with the intention of controlling myopia progression.

Randomised, masked studies have shown that both dual-focus and centre-distance multifocal contact lenses can reduce progression of both axial length growth and refractive change compared to single vision contact lens controls. Reductions of up to 80% in the first year have been published, but tend to average around 45% in the first year and a little less in subsequent years.^{6,7}

Orthokeratology

Orthokeratology (ortho-k) contact lenses are specifically designed to be worn while sleeping. They flatten the front surface of the corneas during the night, which reduces the eyes' optical power. The lenses are removed upon waking, but the corneas hold their new shape during the day, providing myopia correction without wearing any lenses during the day.

Ortho-k has been used for many years for myopia correction, but more recently was shown to affect myopia progression. While the exact mechanism for myopia control with ortho-k is unknown, peripheral myopic defocus appears to play a role. Modern ortho-k

lens design creates a flatter central cornea and steeper peripheral cornea resulting in relative peripheral myopic defocus. Published studies have shown a reduction in the rate of increase of axial length of up to 50% over 2 years.⁸ Concern has been expressed regarding infection risk associated with ortho-K. While no significant adverse events were caused by orthoK in the largest longitudinal studies published,^{8,9} it is certainly worth giving due attention to maintenance of patient/lens hygiene and follow-up care.

Combination therapy

There are limited data available from randomised, controlled clinical trials as to what happens when interventions are combined; e.g., if low-dose atropine eye drops are combined with dual-focus contact lenses. However, a recent pilot study suggests that using orthoK with low-dose atropine is more effective in reducing the rate of myopia progression than ortho-k alone.¹⁰

Not recommended

Peripheral plus spectacles

Animal models have suggested that peripheral myopic defocus can produce central hyperopic growth that can override myopic growth signals from central vision.³ In practical terms, these spectacles could provide clear central vision while controlling myopia progression by blurring peripheral vision. However, the theories and models have not been translated to success in human trials. Peripheral plus spectacles are not a proven intervention and so we do not recommend them at this stage.

Under-corrected spectacles

Evidence of the effect of under-correction of myopia is weak and mixed. There are some results that suggest faster progression with under-correction, while other results suggest slower progression with under-correction.⁴ We do not recommend employing this strategy unless more robust evidence suggests it is worthwhile.⁵

Key messages

Myopia correction should be carried out as early as possible to improve quality of life, productivity and educational performance.

Myopia, once present, progresses over a number of years. It is worthwhile considering the following optical interventions that reduce myopic progression as well as correct myopia:

- **PAL spectacles with +2D near addition** reduce progression by 24% over three years, but only for children with accommodative insufficiency and convergence excess.
- **Executive bifocal spectacles with +1.5D near addition** reduce progression by 50% over three years, but results need to be replicated in a multi-centre trial with masking.
- **Specially-designed contact lenses** (dual-focus soft, centre-distance multifocal soft, and ortho-k) can reduce myopia progression by up to 50% over 2 years. These tend to be expensive and are available mainly in high-income settings.

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Orthokeratology lenses are worn at night to change the shape of the cornea. They have been shown to reduce the rate of axial elongation by 50%. AUSTRALIA



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Pharmacological interventions in myopia management

Daily low-dose atropine has been shown to result in a reduction of close to 60% in myopia progression over 5 years – with little to no rebound effect.



Myopia can get worse very quickly. Drugs such as low-dose atropine can help. CAMBODIA
DEAN SAFFRON, COURTESY OF BRIEN HOLDEN VISION INSTITUTE FOUNDATION

The myopia epidemic has been described across several articles in this issue of the *Community Eye Health Journal*. The long-term burden on the health care system, the global economy and individual quality of life requires that we do what we can to avoid or delay myopia onset and, when myopia is present, that we provide optical correction and do our best to slow its progression. Behaviour modifications such as increased time outdoors and reduced near work appear useful in avoiding or at least delaying onset of myopia, but have not been shown to slow progression once myopia is present. There is evidence that optical interventions (p. 19) and the pharmacological options presented here can reduce myopia progression in children. This may reduce the risk of vision impairment later in life from complications such as retinal detachment and myopic macular degeneration.

Daily low-concentration atropine

Daily low-dose atropine has been shown to result in a 59% reduction in myopia progression over 5 years, and it is virtually asymptomatic.

High quality (large cohort, randomised, masked and controlled) trials of 0.01%, 0.025% and 0.05% atropine eye drops have demonstrated significant myopia control effects over 1 year of daily use.^{1,2} The ATOM2 study showed a 59% reduction in myopia progression over 5 years (which included periods of use and periods of non-use).¹

This myopia control effect was measured by changes in spherical equivalent refraction; it is less clear whether low-concentration atropine controls myopia progression measured by axial elongation. This is an important distinction because we suspect that axial length is a stronger determinant than spherical equivalent of lifelong risk of complications such as

retinal detachment and myopic macular degeneration. However, further studies are required to confirm this.

Daily 0.01% atropine shows little to no rebound effect when treatment is stopped, but the potential rebound effect of the other low concentrations is unknown.^{1,2} Depending on uveal pigmentation and individual sensitivity, these dosages have subclinical effects on pupil size and accommodation, and are therefore very well tolerated.^{1,2}

Low-concentration atropine: unresolved questions

Unsettlingly, we do not know exactly how atropine reduces myopia progression. Atropine has a dose-related effect on accommodation, pupil size, dopamine levels in the retina, and scleral fibroblast activity. Any or all of these mechanisms potentially explain atropine's myopia progression effect, as this effect also appears to be atropine dose-related, as does post-treatment rebound. However, retinal dopamine levels and/or scleral fibroblast activity appear the most likely candidates.

Low-concentration atropine: the challenges

Low-concentration atropine needs to be compounded in most countries, making it too expensive for many people who would benefit from it. It is also commonly an 'off-label' use – meaning reduction in myopia progression was not the reason atropine was approved for use in most countries, which can cause insurance and payment issues. Absence of a local compounding pharmacy can be overcome – compounding pharmacists commonly post or courier drops to patients, even between countries, depending on drug importation rules. The biggest problem remains cost. Pharmaceutical companies have not shown an interest in commercially manufacturing low-concentration

atropine because of regulatory hurdles in countries they are most likely to make profits in. This may change if preferred dosage and axial length effectivity questions are resolved.

We have not observed any significant complications from daily low concentrations of atropine, and none have been reported. However, given the potential complications of atropine generally, caution is warranted. Practitioners should note contra-indications (e.g., Down's Syndrome or spastic paralysis), provide patient information (including critical information about complications), advise sun protection if prescribing concentrations above 0.02%, and advise to return immediately or attend a hospital emergency department if signs of adverse reactions are observed.

Recommendation

Given the current evidence, our recommended regimen is **0.01% atropine, one drop in each eye once a day** (preferably at night, just before bed). We recommend reviewing patients one week after the initiation of atropine use to assess visual function (including distance visual acuity, refraction, accommodation accuracy, and pupil reactions) and to check for any adverse reactions.

After that, it is sensible to regularly review a child with progressive myopia as usual, e.g., every 6–12 months. The practitioner should have clear criteria for ceasing atropine management (e.g., a wash-out period after each 2 years of use, as used in the ATOM studies).² Various groups are actively investigating the effects of a range of low-concentration atropine regimens on myopia progression. Recommendations may change as future studies are published.

Avoid daily regular-concentration atropine

We *do not* recommend the use of daily regular-concentration atropine. Although 1% atropine is widely available, and high-quality randomised controlled trials of 0.1%, 0.5% and 1% atropine eye drops have demonstrated strongly significant myopia control effects over 2 years of daily use,^{1,3} there is a significant rebound effect. One year after ceasing 2 years of daily 1% atropine, study participants showed almost as much cumulative myopia progression as if atropine had never been used.¹ Several options for reducing the rebound effect have been proposed (e.g. tapering atropine in either concentration or frequency of use), but none has been shown safe in prospective randomised controlled trials.

Other candidates

Pirenzepine

The use of pirenzepine 2% twice a day has been shown to have a significant myopia control effect over 2 years⁴ There have been no studies about progression once treatment has stopped, so there is no information about a potential rebound effect. We are unaware of any jurisdictions in which pirenzepine is commercially available.

7-methylxanthine

7-methylxanthine (7-mx) appears to exhibit a safe, significant myopia control effect in both animals and humans.⁵ As is the case with pirenzepine, there have been no studies about progression once treatment has stopped, so there is no information about a potential rebound effect. Denmark is the only jurisdiction we are aware of in which 7-mx is available and permitted for use.

Conclusion

Daily, low-concentration atropine appears safe and beneficial, leading to a 59% reduction in myopia progression over 5 years as measured by spherical equivalent refraction. This has the potential to reduce the frequency of high myopia by over 73%⁶ and reducing the risk of visual impairment associated with higher myopia.

Even so, questions remain about the mechanism of action, efficacy (e.g., does it moderate progression of axial elongation?), the optimal dosage for myopia control, the effect of place and/or ethnicity on optimal dosage, and how atropine interacts with other myopia control interventions (e.g., does combining atropine with dual focus contact lenses or bifocal spectacles result in additive myopia control, does it multiply the effect, or do they interfere with each other?).

We advocate the evidence-based role of daily low-concentration atropine in moderating myopia progression so long as a clear administrative framework, patient safety protocols and drug cessation guidelines are employed.

In our opinion, this currently means considering prescription of 0.01% atropine for use in both eyes, once per day, at night, in appropriate patients.

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Sustaining trachoma elimination: lessons from North Africa and the Middle East

Governments play a leading role in successful trachoma elimination programmes.

There has been significant progress to eliminate trachoma as a public health problem in the Eastern Mediterranean region. In 2012, Oman became the world's first country to be validated by the World Health Organization as having eliminated the disease, followed by Morocco in 2016 and the Islamic Republic of Iran in 2018.¹

Government leadership, and a commitment to protect the 10.4 million people at risk of trachoma in the region have led to more than 11 million doses of antibiotics being distributed there since 2001. Access to clean water and sanitation has also improved, contributing to a reduction in transmission. However, as more countries move towards elimination targets, new strategies are needed so that national eye health care services are able to monitor, track and manage any new cases that occur and thereby prevent a resurgence of trachoma. Recent experience from Oman, Morocco and Iran provide valuable lessons.

Morocco

In 2005, Morocco developed a robust system of epidemiological surveillance to monitor its five formerly endemic provinces. Surveillance included screening in schools, exhaustive house-to-house screening for trachomatous trichiasis (TT) and population-based surveys that included the country's most disadvantaged populations. The system was integrated into existing national epidemiological surveillance in order to improve sustainability and reduce costs.

Trachoma is continuously monitored. At the community level, school health nurses screen all primary school children through its national school health programme. Nurses at local health facilities are trained to identify and treat trachoma whenever it appears. If trachoma is detected, an investigation is conducted that includes screening of the affected person's family and close contacts. Adults are screened for TT as part of routine primary health care visits.

Access to primary health care in Morocco has been extended to 100% of the population. By integrating trachoma activities into national eye health plans, Morocco has ensured that cases are identified and managed before the disease can spread.

Oman

Oman's work to sustain elimination demonstrates the importance of integrating surveillance into existing programmes. Most significantly, Oman integrated trachoma surveillance into its routine health services and its national school programme. Doctors at local health centres are trained to identify trachoma and school health nurses are trained to refer suspected cases to the nearest ophthalmologist. When trachoma is identified, the following steps are taken as per ministry of health guidelines:



Screening for trachomatous trichiasis. OMAN

- 1 Trachoma screening is conducted for all people who live with the patient.
- 2 Antibiotics are provided to clear infection.
- 3 Health and ocular hygiene education are provided.
- 4 The governorate's (region's) epidemiologist documents each case via the electronic Al-Shifa 3+ case monitoring system.

Islamic Republic of Iran

Iran achieved trachoma elimination without a stand-alone programme. Trachoma was eliminated through comprehensive primary health care services and broader development objectives, such as universal access to clean water and sanitation. The steering committee for the country's national water programme is committed to providing water, sanitation and hygiene (WASH) services and continued education about facial cleanliness to areas where poor environmental sanitation remains.

The Islamic Republic of Iran demonstrates that, with strong health systems and social improvements, trachoma can be eliminated without relying on donated medicines. Iran placed a strong emphasis on establishing and strengthening its health care network, which now reaches nearly all rural areas covered by the national primary health care system.

Conclusion

Post-elimination activities in Oman, Morocco and Iran showcase the essential element of national government leadership in their successful programmes and the importance of integrating programmes into existing systems for monitoring the health of the nation.

All national trachoma programmes and their partners can learn from these positive examples of government leadership in order to integrate ongoing surveillance and response into national eye health plans and to include elimination efforts within the WASH sector and school health programmes. This will be crucial in order to sustain the elimination of trachoma as a public health problem.

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Advancing a standardised approach to onchocerciasis elimination mapping

The focus in onchocerciasis is shifting from the control of disease to the elimination of transmission. Completing onchocerciasis elimination mapping is key.

Onchocerciasis, also known as river blindness, is classified as a neglected tropical disease. It causes visual impairment and blindness, stigmatising skin disease and severely debilitating itching. It was estimated in 2017 that there were 20.9 million people infected with onchocerciasis, of whom 14.6 million were suffering from skin disease and 1.15 million were visually impaired or blind.¹

The donation of the medicine ivermectin (Mectizan®) by Merck & Co., Inc. (which operates as MSD outside of the United States and Canada), and the subsequent reductions in disease prevalence, has seen a shift in focus from control of clinical disease to elimination of disease transmission. There are still 205 million people living in known endemic areas, although the risk of infection to most people is low, as long as Mectizan distribution continues.² Elimination of onchocerciasis transmission will ensure that this risk is removed for good, permanently protecting the health and eyesight of millions of people.

Previous mapping efforts focused on identifying the moderate to high endemic areas for priority treatment. In the context of elimination, however, low endemic areas (classified as hypo-endemic areas during previous surveys) must also be identified. Treatment must be instigated in any such area where there is ongoing transmission.

Elimination of onchocerciasis can be achieved if it is possible to increase the rate at which onchocerciasis elimination mapping is completed. In collaboration with ministries of health, WHO/ESPEN (the expanded special programme to eliminate NTDs in Africa and in Yemen), the Bill and Melinda Gates Foundation, Sightsavers and other partners have begun a series of pilot studies to test and refine the tools and strategies that will be needed for OEM. The overall aim is to operationalise and scale-up the draft OEM protocols outlined by the WHO Onchocerciasis Technical Advisory Subgroup (OTS), and to provide data and learning to support their refinement and wider use.

The first phase of OEM pilot studies were successfully completed in 2018 in Ghana and Nigeria. The studies verified onchocerciasis endemicity status in several important implementation units (the administrative level at which each country decides mapping should be conducted) and provided opportunities to test and validate the proposed protocol and data flow system. Best practices were developed and tested in relation to the operational roll-out of OEM, including field-level data collection, technical and epidemiological support, and quality control (embedded in every process). A comprehensive training package for mapping teams, and a framework for preparatory desk-based data reviews, were also developed and tested.

Ministries of health will have access to real-time information on OEM as it is conducted. They will



The OEM survey team get ready to screen community members in Sokoto. NIGERIA

receive standardised outputs from the electronic data capture platform, which will allow them to integrate validated data into national databases and make it easier to report to WHO/ESPEN. Detailed cost analysis is underway to develop accurate cost estimations at the implementation unit level.

The necessary preparatory work is underway for the final part of the OEM pilot; to conduct mapping in Mozambique in mid-2019 in several implementation units. Findings from the latest WHO OTS meeting in February 2019 are currently being included in planned activities in Mozambique. Due to the devastating impact of cyclone Idai, we are closely monitoring the situation and will work with our Mozambique partners to assess the most appropriate time for completion of this work.

On completion, the consortium will be able to offer national programmes and partner organisations in the remaining countries in need of OEM a fully piloted, costed approach to operationalising the OEM protocols outlined by the OTS on a quality-assured online platform. We anticipate that these countries will require close technical guidance from WHO/ESPEN to assist with the prioritising of areas to be mapped.

Integral to the successful roll-out of OEM pilots to date has been ensuring close ties, collaboration and coordination with partners, key stakeholders and experts.

These pilot studies are an essential step in facilitating the rapid expansion and acceleration of OEM while ensuring rigorous data quality standards are maintained.

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Test your knowledge and understanding

These questions are designed to help you to test your own understanding of the concepts covered in this issue.



A child is measured for spectacles. INDIA

UMESH WARISE, COURTESY OF IAPB

We hope that you will also discuss the questions with your colleagues and other members of the eye care team, perhaps in a journal club. To complete the activities online – and get instant feedback – please visit www.cehjournal.org

Tick ALL that are TRUE

Question 1 When considering the management of myopic children:

- a. It does not matter at what age the intervention is implemented; it has the same effect throughout childhood
- b. Under-correction using spectacles is preferred as the first choice of intervention
- c. There is not much difference between the amount of myopic progression resulting from the use of progressive addition lenses (PALs) and executive bifocal spectacles in children
- d. It is possible that combining orthoK with low-dose atropine to reduce the rate of myopia progression has an additive effect

Question 3 When detecting myopia

- a. It is important to ask questions about the person's family eye health history
- b. Visual acuity should always be measured for both eyes separately, followed by pinhole acuity
- c. If pinhole acuity improves, this suggests the patient is myopic. It is not necessary to do any further eye health checks
- d. Multiple pinholes are easier for young children to use than single pinholes

Question 2 In children at risk of developing myopia:

- a. It is advised that they spend a minimum of 90 minutes of outdoor time daily
- b. It is ideal to compare non-cycloplegic refractions over at least 12 months
- c. Measuring axial length increase is recommended to predict myopia progression
- d. It is a good idea to record data on ethnicity, family history of myopia, time spent outdoors and time spent on near work

Question 4 Considering the myopia epidemic

- a. Myopia is currently associated with an increase in urbanisation, reduced educational pressures and moderate near work
- b. Children are more likely to develop high myopia (≤ -5 D) if they become myopic at a young age (6–8 years old)
- c. One strategy is for all school children to spend time outdoors as this delay or prevent the onset of myopia, and slow down myopia progression
- d. A 25% reduction in incidence among primary school children would mean a significant delay in onset of myopia and perhaps high myopia

ANSWERS

1. a. False. It is essential to implement the intervention during the early years of childhood. b. False. Evidence of the effect of under-correction of myopia is weak and this strategy is not recommended. c. False. PAL spectacles with +2D near addition: 24% control over 3 years. Executive bifocal spectacles with +1.5D near addition: 50% control over 3 years. d. True.
2. a. True. b. False. Cycloplegic refraction is more accurate. c. False. Measuring axial length increase may assist when assessing children prescribed orthokeratology. However, be aware that axial length increases with age, even in children with emmetropia. d. True.
3. a. True. Myopia is heritable, particularly if both parents have myopia. However, it also depends on environmental factors. b. False. Pinhole acuity is only indicated when a patient is not able to see the 6/6 line. c. False. A full eye health check is always required, even if pinhole acuity improves the vision. d. True.
4. a. False. Myopia is currently associated with increased educational pressures and excessive near work, particularly in East Asian populations. b. True. Myopia progresses faster in children who are young (6–8 years old, or even younger). Myopia continues to progress until adolescence, so younger children also have more time during which their myopia can develop. These children are therefore more likely to have high myopia when they enter adulthood. c. False – spending time outdoors does not slow down the progression of myopia in those children that are already myopic. However, if children become myopic only when they are older, their myopia will progress more slowly, as myopia progression is slower in older children (10–12 years old) than in younger children (6–8 years old). d. True.

Picture quiz



DAVID YORSTON

Tick ALL that are TRUE

Question 1

What is wrong with this eye?

- a. Dry age-related macular degeneration
- b. Retinitis pigmentosa
- c. High myopia
- d. Primary open-angle glaucoma

Question 2

Which of the following are more common in patients with this condition?

- a. Retinal detachment
- b. Choroidal neovascularisation
- c. Acute angle-closure glaucoma
- d. Open-angle glaucoma
- e. Ptosis

Question 3

Which of the following have been shown to delay the onset or the progression of this condition?

- a. Not wearing spectacles
- b. Avoiding playing sports
- c. Using low-dose atropine drops
- d. Spend more time outside
- e. Avoiding sunlight

ANSWERS

1. c. It is high myopia. There is tilting of the optic disc with chorio-retinal atrophy around the optic disc and throughout the fundus, associated with a pale retina due to atrophy of the retinal pigment epithelium.
2. a, b and d. Retinal detachment, choroidal neovascularisation and open angle glaucoma are all associated with high myopia.
3. c and d. Spending more time outside has been shown to prevent or delay the onset of myopia and low-dose atropine has been shown to reduce progression of myopia in school-aged children.

British Council for Prevention of Blindness Grant Programme

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CEHJ app

Work is underway to develop an Android and iPhone app for the *Community Eye Health Journal*. The CEHJ app will make it possible to download articles and issues to read – and search – even when you are offline.



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Erratum

Due to a printing error, the last three bullet points in the article 'Emergency management: acute endophthalmitis' were not printed.

The instructions for preparing ceftazidime 2 mg/0.1 ml for intravitreal injection are as follows:

Ceftazidime 2 mg/0.1 ml

- Reconstitute 500 mg vial with 10ml saline
- Withdraw all 10ml into 10ml syringe
- Inject 2 ml of this solution back into vial
- Add 3ml saline into vial to make up to 5ml (20mg/ml)
- Use 1 ml syringe to draw 0.1 ml of this solution (2 mg/0.1 ml)

The corrected article is available here: www.cehjournal.org/article/emergency-management-acute-endophthalmitis/

Courses

MSc Public Health for Eye Care, London School of Hygiene & Tropical Medicine, London, UK

Fully funded scholarships are available for Commonwealth country nationals. For more information visit www.lshtm.ac.uk/study/masters/mscphec.html or email romulo.fabunan@lsthm.ac.uk

Small Incision Cataract Surgery Training at Lions Medical Training Centre in Nairobi, Kenya

Courses begin every six weeks and cost US \$1,000 for training and approximately

US \$1,000 for accommodation. Email training@lionsloresho.org or call/message +254 728 970 601 or +254 733 619 191.

Myopia calculator and courses

Brien Holden Vision Institute Academy offers a series of online courses (free and paid) and a free online myopia calculator that allows practitioners to model the impact of various strategies to control the progression of myopia. Visit <https://academy.brienholdenvision.org>

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Next issue



RACHEL PALMER/SHUTTERSTOCK

The next issue of the *Community Eye Health Journal* is on the theme **Medical errors in eye care**

Key community eye health messages

Myopia is an epidemic that needs to be managed



EDGARDO CONTRERAS

- Uncorrected myopia is the leading cause of avoidable blindness worldwide.
- Myopia (≤ -0.50 D) and high myopia (≤ -5 D) is on the increase. By 2050, half the global population could have myopia.
- This will place a huge burden on already overstretched health budgets, not only to provide spectacle correction, but also to treat the potentially blinding conditions caused by high myopia.

The onset of myopia can be prevented or delayed



GOVERNMENT OF SINGAPORE

- Spending more time outdoors and less time doing close work can prevent or delay the development (onset) of myopia.
- Myopia progresses faster in younger children. Progression slows down during adolescence and ends in early adulthood.
- As a result of faster progression and more time during which progression can take place, younger children are more likely to eventually develop high myopia.

Myopia can be managed and progression slowed down



KAREN SPARROW, COURTESY OF IAPB

- Children with myopia need spectacles in order to achieve at school. Early detection and referral is essential, and school eye health programmes play an important role.
- Slowing down progression reduces the risk of developing high myopia. Interventions include daily low-dose atropine, bifocals and orthokeratology lenses. Time outdoors does not slow down progression.
- It is important to measure myopia progression in order to check how effective a particular intervention is.