CLINICAL REVIEW

Management of refractive errors

Gillian M Cochrane,[1 2] Rènée du Toit,[3] Richard T Le Mesurier[1 4 5 6]

[1]Centre for Eye Research Australia, University of Melbourne, Royal Victorian Eye and Ear Hospital, Melbourne, Australia
[2]Vision Cooperative Research Centre, Sydney, Australia
[3]The Fred Hollows Foundation New Zealand, Auckland, New Zealand
[4]The Fred Hollows Foundation, Sydney, Australia
[5]International Agency for Prevention of Blindness, Western Pacific Region, Melbourne, Australia
[6]International Council of Ophthalmology Uncorrected Refractive Error Committee, San Francisco, United States

Correspondence to: G Cochrane, CERA, 32 Gisborne St, East Melbourne VIC 3002, Australia
cochrane.gm@gmail.com

Cite this as: *BMJ* 2010;340:c1711
doi: 10.1136/bmj.c1711

Uncorrected refractive error accounts for half of the global burden of avoidable vision impairment and nearly a third of the global burden of avoidable blindness.[1 2] Globally, 153 million people have visual impairment or are blind due to uncorrected refractive error and the majority live in low income countries.[1] Additionally, 410 million people have difficulty with near tasks because they lack reading glasses.[2] Interventions to treat refractive error, such as spectacles, are cost effective and in high income settings are readily accessible, but refractive errors are often not diagnosed or referred and barriers to the use of services exist.[1] Under-corrected refractive error can account for as much as 75% of all impairment of vision in high income countries [1 3-5] and it may markedly affect quality of life.[5] Minor reduction in vision (<6/12 or just below the driving standard) has been associated with an increased risk of death and physical, social, and psychological problems in people older than 50 years (see box 1 on bmj.com).[6 w1-7] The global economic impact of uncorrected refractive error is an estimated 268.8 billion international dollars, based on population and economic data combined with a meta-analysis of prevalence studies.[7] We provide an overview of the public health significance of refractive error, its management, and referral strategies for primary care practitioners.

What causes refractive error?

Part A of the figure shows a normal eye with the light focusing on the retina (emmetropia). Refractive error occurs because of an inability of the eye's anatomical and physiological components to focus light on to the retina (ametropia). Myopia (short-sightedness) occurs when light is focused in front of the retina causing blurry distance vision (fig, B). Near vision is still maintained, although people with high levels of myopia will need to hold objects close to their eyes to see them clearly. Hypermetropia (hyperopia; long-sightedness) occurs when light is focused behind the retina, although the natural ability of the eye to focus (accommodation) often allows light to be brought into focus onto the retina (fig, C). An individual's age and the degree of hyperopia determine the extent of their ability to accommodate. With a minor degree of hyperopia a younger person's distance and near vision is often clear but they may experience asthenopic symptoms ("tiring" of the eyes often characterised by visual discomfort or headache). With age, near vision and eventually distance vision may be compromised as reduced flexibility of the crystalline lens limits the ability to accommodate. Age-related inflexibility of the lens causes presbyopia (increasing difficulty in seeing clearly when attempting close-range tasks, for example, within arm's length), which naturally occurs irrespective of other refractive errors from about age 40 onwards. The initial signs include accommodative lag (slower recovery time changing from distance to near tasks and vice versa); increasing difficulty with accommodation in reduced light conditions; and tiring with continuous close work. Astigmatism occurs when the eye's optical system cannot produce a point focus (fig, D) causing a blurry image. It usually occurs in conjunction with either myopia or hyperopia and thus also presbyopia.[w8]

Some systemic and ophthalmic conditions may change refractive status. A decrease in visual ability due to field loss, reduced light-dark adaptation, or changes in colour vision and contrast sensitivity may be mistaken for a change in refractive error. Taking a careful history helps to ensure appropriate referral.

Who is affected by refractive error and when?

Children

Hyperopia and astigmatism are often present at birth but usually resolve by age 3 years (emmetropisation).[8] By contrast, preterm babies are myopic.[9]

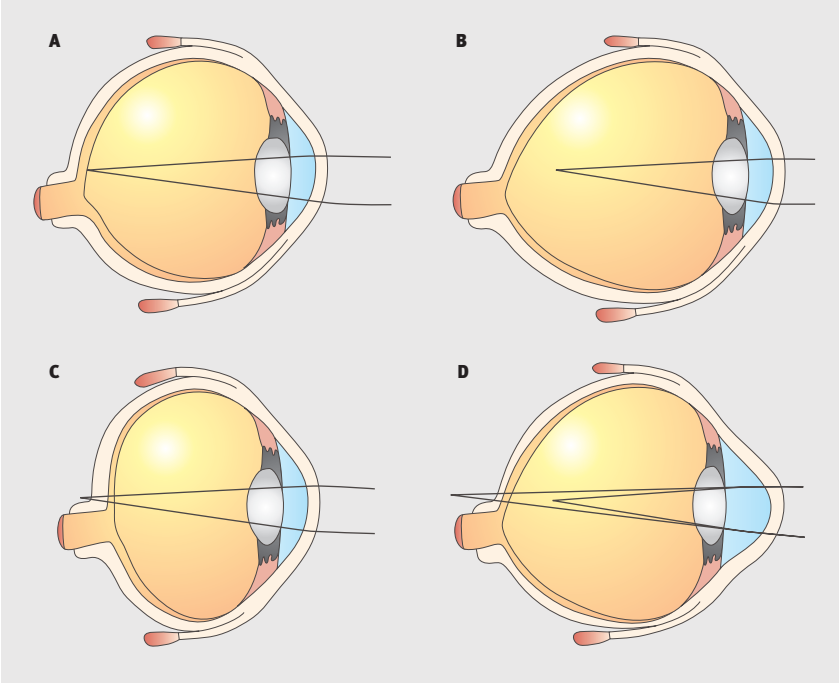
In a series of population based surveys, the prevalence of refractive errors in children aged 5-15 years varied substantially between geographic regions, urban and rural locations, and different ethnic groups.[10] If refractive error is not detected children may develop behavioural problems or fall behind their peers in education and social functioning.[1 11 w11]

SUMMARY POINTS

- Uncorrected and under-corrected refractive error is the leading global cause of avoidable vision impairment
- The rising prevalence of myopia and an ageing population are increasing the need for management of refractive error
- Most refractive errors manifest as a gradual loss of distance or near vision, or symptoms of eyestrain after concentrated visual tasks
- In low income countries refractive error may often be managed by trained mid-level healthcare workers
- Correction of refractive errors usually improves vision, visual comfort, and quality of life.

SOURCES AND SELECTION CRITERIA

In October 2008 and May 2009 we searched the Cochrane Collaboration database for reviews and clinicaltrials.gov for current trials, returning 420 studies. We also searched Medline and PubMed for articles published between 1 January 2000 and 1 May 2009, using MESH terms and combinations including quality of life and public health with uncorrected, refractive error, spectacles, surgical, and management, as well as specific terms relating to refractive error and correction; this search returned 1128 articles, 107 of which were review articles.



(A) Light rays refracted to point focus on to retina in normal eye. (B) Light rays refracted to point focus in front of retina in myopic eye. (C) Light rays refracted to point focus "behind" retina in hyperopic eye. (D) Light rays refracted to two distinct point foci, neither necessarily focused on retina in astigmatic eye

Myopia typically manifests in adolescence or early adulthood in people undertaking tertiary education. Cross-sectional samples of students from cohort studies show a trend towards myopia in 6 and 7 year olds in urban areas in East Asia.[12 w9] Undetected myopia may adversely affect social interaction and performance in class or sports. Myopia receives more attention as a public health issue than hyperopia,[12 w10] yet uncorrected hyperopia can also adversely affect education in school aged children.[11] Hyperopia may underlie strabismus and jeopardise stereopsis (perception of depth), causing amblyopia. It may also make close work tiring and difficult.

Adults

An ageing global population has increased the prevalence of presbyopia. A meta-analysis of population surveys estimated that 517 million individuals have uncorrected presbyopia, 410 million of whom would be restricted in performing near tasks such as reading or preparing meals.[2]

How can a primary care practitioner recognise refractive error?

Patients with uncorrected refractive error will find it difficult to see clearly or comfortably. A careful history will note previous ophthalmic and known vision problems and the interval since these were last addressed. Since changes in vision are gradual and may be attributed to ageing, individuals may not specifically mention symptoms.[4] The most commonly mentioned symptoms relate to daily tasks such as driving, reading household bills or medication instructions, and food preparation. These symptoms may manifest as a loss of confidence or depression.[w4] The individual's age and occupation are important to note. Associated complaints may include headaches, sore, red, watery, or tired eyes, which may be linked to specific tasks.[w8] Parents may report that younger children habitually rub their eyes or turn their heads when looking at things, or sit too close to the television. School aged children may present only with behavioural problems or apparent learning difficulties.[11 w11]

Testing each eye separately for distance and near vision is the simplest and most effective way to determine whether vision is impaired. If visual acuity at six metres is worse than 6/12 in adults or worse than 6/9 in children, referral for optometric examination is indicated. Details of referral criteria for children are shown in box 2. Referral is also indicated if near vision, tested at the patient's usual reading distance, is worse than N5. The table provides a guide to measurements of visual acuity.

What other conditions are associated with refractive error?

In children (0-15 years) the most common ocular conditions associated with refractive error are strabismus (abnormal alignment of one or both eyes) and amblyopia (an uncorrectable decrease in vision without a structural abnormality to explain it). A review of randomised control trials and population surveys estimated that the prevalence of amblyopia is 3% for those <8 years.[13] Large differences in refractive error between fellow eyes (anisometropia) or high levels of hyperopia may cause strabismus and amblyopia.

Keratoconus is a cause of myopia and irregular astigmatism in adolescents that is best corrected by rigid contact

Box 2 | Recommendations for frequency of eye examinations

Adults

Asymptomatic low-risk patients

- Age 19-40 years: at least every 10 years
- Age 41-55 years: at least every 5 years
- Age 56-65 years: at least every 3 years
- Age >65 years: at least every 2 years*

Symptomatic patients

Any patient noting changes in visual acuity, visual field, colour vision, or physical changes to the eye requires an eye health examination as soon as possible.

Patients at high risk of visual impairment

For example, those with diabetes, cataract, macular degeneration, or glaucoma, or with a family history of these conditions

Age >40 years: at least every 3 years

Age >50 years: at least every 2 years

Age >60 years: at least every year

Children aged 5 years and older†

Younger children should be assessed by an optometrist or ophthalmologist who provides paediatric care

Non-urgent referral

If visual acuity is 6/9 (20/30) or worse, or in the presence of

- a two line difference in visual acuity between eyes, or
- strabismus or suspected strabismus, or
- difficulty in achieving a reliable visual acuity measurement.

Semi-urgent referral

Visual acuity 6/60 (20/200) or worse.

*Level 1; based on Australian study by Taylor HR, Vu HT, McCarty CA, Keeffe JE. The need for routine eye examinations. *Investigative Ophthalmology Visual Science* 2004;45:239-42.

†Canadian Ophthalmological Society and Clinical Practice Guideline Expert Committee. *Can J Ophthalmol* 2007;42:39-45. Available at http://pubs.nrc-cnrc.gc.ca/cjo/cjo42/i06-126e.pdf.

Visual acuity measurement conversion table

	Method of measurement					
	Snellen metric	Snellen empirical	Snellen decimal	LogMAR distance	M units (near)	Equivalent N
Bottom row on most charts	6/5	20/17	1.2	−0.1	M0.3	N2.5
Normal/average	6/6	20/20	1.0	0.0	M0.4	N3
	6/7.5	20/25	0.8	0.1	M0.5	N4
	6/9	20/30	0.67	0.2	M0.6 (0.63)	N5 (medicine labels)
Minimal level required for driving	6/10	20/33	0.6	–	–	–
	6/12	20/40	0.50	0.3	M0.8	N6 (normal/average ability)
Mild vision impairment (‹6/12 to ≥6/18)*	6/15	20/50	0.4	0.4	M1.0	N8 (newspaper)
	6/18	20/60	0.33	0.5	M1.3 (1.25)	N10 (books)
Moderate vision impairment (‹6/18 to ≥6/60)	6/24	20/80	0.25	0.6	M1.6 (1.5)	N12 (books and magazines)
	6/30	20/100	0.20	0.7	M2.0	N16
	6/36	20/120	0.17	0.8	M2.5	N20
	6/48	20/160	0.12	0.9	M3.0 (3.2)	N24
Top letter/row on most charts†	6/60	20/200	0.10	1.0	M4.0	N32
Severe vision impairment (‹6/60 to ≥3/60)	6/75	20/250	0.08	1.1	M5.0	N40
	6/95	20/320	0.06	1.2	M6.0 (6.3)	N48
	3/60 (6/120)	20/400	0.05	1.3	M8.0	N64
‡	3/75 (6/150)	20/500	0.04	1.4	M10.0	N80
	3/95 (6/190)	20/630	0.03	1.5	M12.5	N100
	3/120 (6/240)	20/800	0.02	1.6	M15	N120
Counting fingers	1/60 (6/480)	20/1600	0.01	1.8	M25	N200
Hand movements and ability to identify light/dark	PL (perception of light)	–	–	3.0	M400	–
Blind	NPL (no perception of light)	–	–	4.0 (arbitrary number)	–	–

Table extract courtesy of GMC. Logarithm of minimum angle of resolution (LogMAR) systems ensure similar difficulty between rows and geometrical progression in size between each row. LogMAR charts are the measurement of choice for patients with impaired vision because visual acuity can be measured at different distances accurately and comparatively between patients. M units are a geometric measurement of magnification required to see near type. The equivalent N size (font sizing system used in books and computers) is also shown indicating type size in everyday terms. N point historically comes from typesetting where one point is 1/72 of an inch.

*Often the first level at which children are entitled to specialist support services by government agencies.

†Often the point for support services for adults and referred to as "legal blindness".

‡WHO classification for first level of blindness, using visual acuity alone as the descriptor (‹3/60).

lenses. However, it has a relatively low incidence of about one in 2000 in white populations[14] and one in 500 in Asian populations.[15]

Ocular conditions may accompany chronic diseases in adults. For example, people with diabetes may present with visual loss or fluctuations in visual acuity, which may be associated with refractive error caused by changes in plasma glucose concentrations. However, reduced visual acuity is not a reliable indicator of sight threatening diabetic retinopathy.[16]

How is refractive error typically managed?

Optometrists most commonly evaluate and diagnose refractive error through a specialised eye examination. Ophthalmologists may also manage refractive error, as well as orthoptists and ophthalmic medical practitioners. In low income or rural areas refractionists, such as ophthalmic nurses with training in refraction, may provide varying levels of management for refractive error.[17-19 w12]

Spectacles are the simplest, safest, and most cost-effective way to correct refractive error. In resource rich countries spectacles are used to correct about two thirds of refractive errors.[w13] In many low income settings services and spectacles may be unavailable or unaffordable for most of the population,[4 20] a problem compounded by lack of appropriately trained staff and sustainable supplies of affordable spectacles.[1 2 18 19 w12] Even when correct and cosmetically acceptable spectacles are provided they may not be worn with appropriate frequency, especially by schoolchildren.[21]

Barriers to accessing services in high and low income settings include lack of awareness, fear or mistrust of services or of using correction, inaccessibility of services, and direct and indirect costs. Box 3 (on bmj.com) highlights barriers to the correction of refractive errors.[w14-w17]

How else might refractive error be managed?

Atropine

Drugs have been used to manage myopia. Two randomised controlled trials in Taiwan showed that the progression of myopia was slowed by administering atropine more than by the use of multifocal spectacles or a combination of both.[22 23] This approach could have important public health implications as the prevalence of myopia increases.[w18] Drawbacks include the cost of treatment, photophobia, and difficulty with near work unless bifocals or multifocals are used.

Prevention

Frequent outdoor activity may prevent myopia. A large cross-sectional study of 4132 school students suggested that greater levels of outdoor activity, after accounting for near work and genetic factors, may protect against myopia in 12 year olds.[24]

Contact lenses

A minority of the population with refractive errors makes use of corrective contact lenses, which are used either daily or for extended wear (overnight weekly/monthly).[w13]

Box 4 | Complications associated with contact lens wear (from most to least common)

1 Giant papillary conjunctivitis—an allergic response to solutions or protein deposits usually on soft lenses. Symptoms include discomfort and excessive lens movement that can affect vision. Changes in solutions, wearing regime (including renewing lenses more frequently), or type of lens material may be needed

2 Corneal abrasion—most commonly caused by a foreign body (for example, dust, grit, sand, small seeds) trapped under a rigid lens or a defect such as an edge tear on a soft lens. Can also occur when inserting or removing a contact lens. Discontinue lens wear for at least 24 hours. Medical care is not usually needed unless the abrasion fails to heal

3 Corneal oedema—caused by oxygen deprivation (hypoxia) resulting in hazy vision or haloes around lights. The eye may feel uncomfortable when the lens is removed. Poorly fitted lenses, overwearing lenses, or wearing lenses with poor oxygen transmission can cause oedema. Oedema normally resolves a few hours after lens removal. The cause needs to be addressed by the contact lens practitioner

4 Neovascularisation—new limbal blood vessels that loop back toward the limbus are common. However, with chronic hypoxia, usually caused by overwear of rigid or soft lenses, the limbal vessels may respond by infiltrating further into the cornea progressing towards the pupillary area with associated "clouding" of the cornea (pannus). This problem is potentially sight-threatening and requires discontinuation of lens wear and specialist ophthalmic care

5 Corneal ulceration and microbial keratitis—rarely (for example, microbial keratitis affects five in 10 000 wearers annually). Both serious complications that require urgent treatment by an ophthalmologist to reduce the likelihood of permanent vision loss. Untreated infection can quickly become severe, leading to permanent damage to the infected eye. A virulent organism can cause severe destruction of the cornea within 24 hours. If any redness (usually unilateral) and pain is noted, immediately discontinue lens wear, do not pad the eye, and seek urgent professional ophthalmic advice. Corneal ulcers can be caused by bacterial, fungal, or parasitic amoeba infection. Acanthamoeba infection causes little pain. Ulcers can be due to secondary infection after a corneal abrasion. More commonly, both ulcers and microbial keratitis are as a result of poor lens and lens case hygiene or abusive wear

Non-permeable hard lenses have been largely superseded by rigid gas-permeable lenses, which can be fitted to distort the shape of the cornea in a controlled fashion providing relief from myopic symptoms (orthokeratology) and may slow the progression of myopia. Over 80% of contact lens users wear soft lenses made of hydrogel or silicone hydrogel.

Box 4 lists common complications of contact lens wear; less than 5% of all contact lens wearers experience any complications. Adverse events associated with contact lens wear include an increased risk of invasive limbal corneal vascularisation, corneal ulceration, and specific infections such as acanthamoeba. Compared with daily use of rigid lenses, overnight wear and use of soft contact lenses increase the risk of acquiring ocular infections, for example, they are associated with up to a 25-fold increase in risk of developing microbial keratitis.[w19]

Contact lens wearers who present with red eyes and report hazy vision and persistent pain when removing their lenses may have corneal ulceration or microbial keratitis. Advise them to stop using their lenses immediately and refer quickly to specialised ophthalmology services. A delay in treatment of these conditions could lead to irreparable corneal damage and serious vision loss.

Surgery

Laser in situ keratomileusis (LASIK) and photo-refractive keratectomy (PRK) are popular procedures while use of laser epithelial keratomileusis (LASEK) is increasing. Other surgical treatments for severe myopia include insertion of implants after clear lens extraction (refractive lens exchange). Full thickness corneal graft may be a final option for patients with advanced kerataconus although currently there is interest in new techniques that involve collagen crosslinking. As with any surgical procedure complications may arise post-operatively (box 4). Post-operative monitoring is normally undertaken by the specialist ophthalmic surgical clinic and optometry services. Patients are usually informed pre-operatively about what to expect and where to go if they suspect complications. Any patient reporting pain and redness after surgery should be referred urgently to their ophthalmic surgeon.

Managing strabismus and amblyopia

Strabismus related to high degrees of refractive error can be treated effectively with refractive correction; sometimes occlusion therapy or surgery is needed. Large observational cohort studies found that early detection and management of strabismus (before age 5) reduced the prevalence of amblyopia.[13 w20 w21]

What are the recommendations for frequency of eye examinations?

Adults

Little level 1 evidence is available to support clinical guidelines for the frequency of eye examinations. The Canadian Ophthalmological Society clinical guideline expert committee has produced consensus guidelines derived from prevalence and evaluation studies (box 2).

Generally, if individuals notice changes in their vision, then an eye examination is required. Sudden loss of vision usually indicates an ocular emergency that requires urgent referral to an ophthalmologist.

Comfort of frames and cosmetic concerns may affect quality of life[25] but, as non-clinical considerations, they are sometimes overlooked by practitioners.

Although presbyopia can be corrected adequately with over-the-counter ready made spectacles, it affects people at an age when they are at increased risk of other ocular problems.[2 6] Therefore, it is advisable that people with presbyopia be encouraged to have regular eye examinations to assess ocular health.

QUESTIONS FOR FUTURE RESEARCH

- There is a need to assess the cost-effectiveness for vision screening in older age groups (>50 years of age) and more evidence to support frequency of eye examinations.
- There is still a need for well planned randomised controlled trials to be undertaken in various settings so that the potential benefits and harms of school vision screening and frequency of eye examinations for children can be comprehensively measured.
- Studies to show the effectiveness of other cadres providing refraction services in low income settings are required to provide empirical evidence that: improved coverage (compared to existing) is achieved; improved uptake of services (compared to existing) is achieved, and; that standard of care for straightforward cases is as good as that provided by traditionally-accepted providers of refraction services and refractive error management, that is, optometrists and ophthalmologists.
- Studies considering cost effectiveness of refractive error management regimes; cost of training personnel, placement and retention of personnel, manufacturing and production cost of products and appliances, as well as direct and indirect costs to consumers. Further quality of life outcomes research to provide indications of the comparative effectiveness of refractive error management regimes, for example, quality of life outcomes between spectacle, contact lens wear and refractive surgery; self-esteem of children between contact lens and spectacle wear and between individuals with and without amblyopia.

Children

Few evidence based guidelines are available for management of refractive error in children although it is well accepted that the earlier a child is diagnosed and treated the better (box 2).[26 w22]

Evidence is insufficient to determine the best age at which to screen children for vision problems.[w22] Mathematical modelling of prevalence data showed that screening 5 to 15 year old children is associated with the greatest health benefit but screening 11 to 15 year olds is most cost effective.[27] Recommendations about screening span a range of ages, types of practitioners, and assessments. Pre-school screening (that is, at age 3-4) is considered effective for detecting children with amblyopia, amblyogenic factors, and high refractive errors.[13 w20 w21] A well conducted, randomised crossover study of 1052 children suggested that photoscreening was the most effective screening tool for young children with these conditions.[28]

A series of prevalence studies suggested that the next most effective time to screen for refractive errors is during secondary schooling.[27 w23 w24] Once a child is known to require correction optometrists routinely re-examine children every two years (or annually if in a high risk category).[w25] However, well designed studies are required to provide an evidence base to guide best practice.

What is the value of treating refractive error from a public health point of view?

Vision impairment ranks sixth in the global top ten causes of burden of disease in the terms of disability adjusted life years.[29] In 1999, a partnership between the International Agency for the Prevention of Blindness and the World Health Organization launched VISION 2020, the Right to Sight—a global initiative for the elimination of avoidable blindness and vision impairment by the year 2020. Uncorrected refractive error was designated a priority for intervention because it is easily treatable and yet is a substantial cause of avoidable blindness and vision impairment.[1] It affects a large percentage of the population, is costly for national health services and individuals, and reduces quality of life (box 1 on bmj.com).[1 7] Use of residual vision in those with visual impairment is limited if refractive problems are not addressed.[25] Strong evidence suggests that failure to address refractive error in childhood has lifelong consequences, and that the large untreated adult population imposes a serious burden on society.[1 2 6 7]

Correction of refractive error results in a measurable improvement to quality of life.[25 w26] Some of the barriers to getting treatment may be removed if primary healthcare practitioners ask about vision related problems and make appropriate referrals when refractive error is suspected. Problems of diagnosis and management can be exacerbated by limited access to skilled practitioners, which may require organisational change.[20] A change of practice may help to address uptake of services for individuals limited by lack of funds or those in marginalised groups, such as older people, particularly those with an isolated or sedentary lifestyle.[4 19 30] However, the increasing prevalence of myopia and presbyopia will place greater demands on all primary service providers. Systems for sustainable supplies of affordable spectacles are needed, especially in low income settings, as well as sustainable training of appropriate personnel.[1 18 19 w12] More evidence is needed of the effectiveness and cost effectiveness of using specially trained healthcare workers to provide "refraction-only" services in low income settings.[19 w12]

TIPS FOR NON-SPECIALISTS

- Refer patients who are likely to have refractive errors to specialist ophthalmic staff for further testing of vision
- The earlier childhood problems are identified and managed, the greater the likelihood that the best outcome will be achieved and will be beneficial in adulthood
- Family history of glaucoma, diabetes, and hypertension increase the likelihood of retinopathy and ocular complications for individuals. Advise such individuals to have regular eye examinations by their optometrist and/or ophthalmologist at least once every two years when over the age of 50.
- Weak level 1 evidence supports a recommendation for adults to have an eye test at least once every five years if they have no substantial family history of glaucoma, hypertension and diabetes
- Suspected corneal infection associated with contact lens wear or surgical correction requires urgent referral to an ophthalmologist, as does sudden loss of vision

ADDITIONAL EDUCATIONAL RESOURCES

Resources for healthcare professionals

NHS Evidence—Eyes and Vision (www.library.nhs.uk/eyes)—accessible to any general or specialist health professional involved in eye health care

Association of Optometrists (www.aop.org.uk)—site provides information support including vision standards

Low Vision Online (www.lowvisiononline.unimelb.edu.au)—information in French and English for practitioners and patients

American Association of Ophthalmologists; Ophthalmic News and Education Network (ONE Network) (http://one.aao.org)—the following are two useful documents providing further information on the topics included in this article for general/primary health care practitioners

Pediatric Eye Evaluations: Screening and Comprehensive Ophthalmic Evaluation (http://one.aao.org/CE/PracticeGuidelines/PPP.aspx?sid=d9939a8b-1675-4bf8-85fb-154652305795)

Refractive Errors and Refractive Surgery (http://one.aao.org/CE/PracticeGuidelines/PPP.aspx?sid=d9939a8b-1675-4bf8-85fb-154652305795)

Vision CRC (www.visioncrc.org/mk/index.asp) and Brien Holden Vision Institute (www.brienholdenvision.org/images/stories/pdf/resources/apacguidelines.pdf)—guidelines for general/primary health care practitioners regarding contact lens wear

Optometry clinical practice guidelines of American Optometric Association (www.aoa.org/x4813.xml)—provide useful explanatory introductions to topics

Resources for patients

www.patient.co.uk/showdoc/40025964

www.visionchannel.net/refractivecorrection/index.shtml

http://en.wikipedia.org/wiki/Eyeglass_prescription

http://en.wikipedia.org/wiki/Corrective_lens

This research at the Vision Cooperative Research Centre was partly facilitated by the Australian Federal Government through the Cooperative Research Centres Program and also by the Centre for Eye Research Australia, the University of Melbourne, and the Royal Victorian Eye and Ear Hospital.

Contributors: GMC provided the initial focus, search strategy, design, and first draft of the paper. The literature review was conducted by GMC and RdT. All three authors revised the literature review and contributed to the content, design, and editing of the paper. GMC is guarantor.

Competing interests: All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare that all authors had: (1) no financial support for the submitted work from anyone other than their employer; (2) no financial relationships with commercial entities that might have an interest in the submitted work; (3) no spouses, partners, or children with relationships with commercial entities that might have an interest in the submitted work; (4) no non-financial interests that may be relevant to the submitted work.

1 Resnikoff S, Pascolinia D, Mariott SP, Pokharel GP. Global magnitude of visual impairment caused by uncorrected refractive errors in 2004. *Bull World Health Organ* 2008;86:63-70.
2 Holden BA, Fricke TR, Ho SM, Wong R, Schlenther G, Cronje S, et al. Global vision impairment due to uncorrected presbyopia. *Arch Ophthalmol* 2008;126:1731-9.
3 Vitale S, Cotch MF, Sperduto RD. Prevalence of visual impairment in the United States. *JAMA* 2006;295:2158-63.
4 Evans BJW, Rowlands G. Correctable visual impairment in older people: a major unmet need. *Ophthalmic Physiol Optics* 2004;24:161-80.
5 Chia EM, Mitchell P, Ojaimi E, Rochtchina E, Wang JJ. Assessment of vision-related quality of life in an older population subsample: The Blue Mountains Eye Study. *Ophthalmic Epidemiol* 2006;13:371-7.
6 Taylor HR. Eye care for the future: The Weisenfeld Lecture. *Invest Ophthalmol Vis Sci* 2003;44:1413-8.
7 Smith T, Frick K, Holden B, Fricke TR, Naidoo KS. Potential lost productivity resulting from the global burden of uncorrected refractive error. *Bull World Health Organ* 2009;87:431-7.
8 Mutti DO, Mitchell GL, Jones LA, Friedman NE, Frane SL, Lin WK, et al. Axial growth and changes in lenticular and corneal power during emmetropization in infants. *Invest Ophthalmol Vis Sci* 2005;46:3074-80.
9 Varughese S, Varghese RM, Gupta N, Ojha R, Sreenivas V, Puliyel JM. Refractive error at birth and its relation to gestational age. *Curr Eye Res* 2005;30:423-8.
10 Ellwein LB. Case finding for refractive errors: assessment of refractive error and visual impairment in children. *J Comm Eye Health* 2002;15:37-8.
11 Rose KA, Morgan IG, Smith W, Burlutsky G, Mitchell P, Saw S-M. Myopia, lifestyle, and schooling in students of Chinese ethnicity in Singapore and Sydney. *Arch Ophthalmol* 2008;126:527-30.
12 Williams WR, Latif AHA, Hannington L, Watkins DR. Hyperopia and educational attainment in a primary school cohort. *Arch Dis Childhood* 2005;90:150-3.
13 Webber AL. Amblyopia treatment: an evidence-based approach to maximising treatment outcome. *Clin Exp Optom* 2007;90:250-7.
14 Kennedy RH, Bourne WM, Dyer JA. A 48-year clinical and epidemiologic-study of keratoconus. *Am J Ophthalmol* 1986;101:267-73.
15 Pearson AR, Soneji B, Sarvananthan N, Sandford-Smith JH. Does ethnic origin influence the incidence or severity of keratoconus? *Eye* 2000;14:625-8.
16 Scanlon PH, Foy C, Chen FK. Visual acuity measurement and ocular co-morbidity in diabetic retinopathy screening. *Br J Ophthalmol* 2008;92:775-8.
17 Vincent JE. Simple spectacles for adult refugees on the Thailand-Burma border. *Optom Vis Sci* 2006;83:803-10.
18 Ramke J, du Toit R, Palagyi A, Williams C, Brian G. Public sector refraction and spectacle dispensing in low-resource countries of the Western Pacific. *Clinical and Experimental Ophthalmology* 2008;36:339-47.
19 Vincent JE, Pearce MG, Leasher J, Mladenovich D, Patel N. The rationale for shifting from a voluntary clinical approach to a public health approach in addressing refractive errors. *Clin Exp Optom* 2007;90:429-33.
20 Gilbert CE, Shah SP, Jadoon MZ, Bourne R, Dineen B, Khan MA, et al. Poverty and blindness in Pakistan: results from the Pakistan national blindness and visual impairment survey. *BMJ* 2008;336:29-32.
21 Wedner S, Masanja H, Bowman R, Todd J, Bowman R, Gilbert C. Two strategies for correcting refractive errors in school students in Tanzania: randomised comparison, with implications for screening programmes. *Br J Ophthalmol* 2008;92:19-24.
22 Shih Y-F, Hsiao CK, Chen C-J, Chang C-W, Hung PT, Lin LLK. An intervention trial on efficacy of atropine and multi-focal glasses in controlling myopic progression. *Acta Ophthalmol Scand* 2001;79:233-6.
23 Lee J-J, Fang P-C, Yang I-H, Chen C-H, Lin P-W, Lin S-A, et al. Prevention of myopia progression with 0.05% atropine solution. *J Ocul Pharmacol Thera* 2006;22:41-6.
24 Rose KA, Morgan IG, Ip J, Kifley A, Huynh S, Smith W, et al. Outdoor activity reduces the prevalence of myopia in children. *Ophthalmol* 2008;115:1279-85.
25 Coleman AL, Yu F, Keeler E, Mangione CM. Treatment of uncorrected refractive error improves vision-specific quality of life. *J Am Geriatrics Soc* 2006;54:883-90.
26 Braverman R. Diagnosis and treatment of refractive errors in the pediatric population [pediatrics and strabismus]. *Curr Opin Ophthalmol* 2007;18:379-83.
27 Baltussen R, Naus J, Limburg H. Cost-effectiveness of screening and correcting refractive errors in school children in Africa, Asia, America and Europe. *Health Policy* 2009;89:201-15.
28 Salcido AA, Bradley J, Donahue SP. Predictive value of photoscreening and traditional screening of preschool children. *J Am Assoc Ped Ophthalmol Strabismus* 2005;9:114-20.
29 Chiang PPC, Keeffe JE, Le Mesurier RT, Taylor HR. Global burden of disease and visual impairment. *Lancet* 2006;368:365.
30 Taylor HR, Keeffe JE, Vu HTV, Wang JJ, Rochtchina E, Pezullo ML, et al. Vision loss in Australia. *Med J Aust* 2005;182:565-8.

Accepted: 22 March 2010

ANSWERS TO ENDGAMES, p 873. For long answers go to the Education channel on bmj.com

STATISTICAL QUESTION

Primary and secondary outcome measures

Answers *a*, *b*, and *d* are true; answer *c* is false.

PICTURE QUIZ

An unusual cause of myocardial infarction

1 The finding of a right adrenal mass raises the suspicion of phaeochromocytoma. This could explain the patient's presentation of profound cardiovascular collapse.
2 Measurement of plasma and urinary metanephrine, computed tomography, magnetic resonance imaging, and positron emission tomography using iodine-123 labelled meta-iodobenzylguanidine (^{123}I-MIBG).
3 Stabilisation of cardiovascular status, α blockade followed by β blockade before delayed surgical resection. Intravascular volume expansion is needed before surgery to avoid the profound hypotension that can be seen in these patients during and after surgery.

CASE REPORT **Evaluation of breast masses in a male patient**

1 Take a detailed history, including age, medical history, details of breast changes, use of medications and illicit drugs, and oestrogen exposure. Ask about changes in sexual functioning and symptoms of oestrogen excess or androgen deficiency, such as decreased libido, overall decreased strength, infertility, sexual dysfunction, and impotence. Carry out a general examination, including the breasts and genitalia, and assess the degree of virilisation.
2 Further investigations are warranted if a detailed history and physical examination show no obvious cause for the breast changes, clinical findings indicate underlying pathology, and clinical findings raise suspicion for malignancy.
3 The tests will depend on the clinical suspicion but could be biochemical tests for endocrine abnormalities, mammography and ultrasound for suspected malignancy, or specific imaging of the scrotum and brain.
4 The clinical findings in this patient are in keeping with gynaecomastia, which can arise as a side effect of treatment with digoxin.
5 Consider using an alternative drug to digoxin. Gynaecomastia is generally managed by withdrawing the inciting drug and treating the hormonal imbalance medically if the symptoms are severe and do not resolve after withdrawal, or if no underlying cause is found. Surgical treatment is reserved for longstanding disease that interferes with daily functioning.