Review of guidelines for children’s vision screenings

Shelley Hopkins, B Optom; Geoff P Sampson, PhD; Peter Hendicott, PhD; Joanne M Wood, PhD FAAO

1School of Optometry and Vision Science, Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Australia

Abstract:

The aim of children’s vision screenings is to detect vision problems that are common in this age category through valid and reliable tests. Nevertheless, the cost effectiveness of paediatric vision screenings, the nature of the tests included in the screening batteries and the ideal screening age has been the cause of much debate in Australia and worldwide. The purpose of this review was to therefore report on the current practice of children’s vision screenings in Australia and other countries, as well as to evaluate the evidence for and against the provision of such screenings. This was undertaken through a detailed investigation of peer-reviewed publications on this topic.

The current review demonstrates that there is no agreed vision screening protocol for children in Australia. This appears to be a result of the lack of strong evidence supporting the benefit of such screenings. Whilst amblyopia, strabismus and, to a lesser extent refractive error, are targeted by many screening programs during pre-
school and at school entry – there is less agreement regarding the value of screening
for other visual conditions such as binocular vision disorders, ocular health
problems and refractive errors that are less likely to reduce distance visual acuity.
In addition, in Australia, little agreement exists in the frequency and coverage of
screening programs between states and territories, and the screening programs that
are offered are ad hoc and poorly documented.

Australian children stand to benefit from improved cohesion and communication
between jurisdictions and health professionals to enable an equitable provision of
validated vision screening services that have the best chance of early detection and
intervention for a range of paediatric visual problems.
The purpose of paediatric vision screenings is to detect children who have, or are at risk of developing, specific age-relevant vision problems. It is important to identify vision conditions in a timely manner as many common vision problems can be managed effectively once identified. In a number of these cases – for example retinoblastoma or amblyopia – early detection reduces morbidity and facilitates successful treatment outcomes. Availability of valid and reliable test batteries is fundamental to this process being successful. There is ongoing debate, however, with regard to the cost effectiveness of paediatric vision screenings, the precise tests that should be included in screening batteries, and the ideal age for administration of these batteries. The issue of what comprises the most appropriate referral criteria for vision screening batteries has, however, received little attention in the literature. This review explores the history of paediatric vision screening, outlines current practice in Australia, and evaluates the evidence base underlying the provision of such screening programs.

Vision conditions that are screened for in childhood include amblyopia and its risk factors (strabismus, anisometropia or congenital cataract), refractive error, colour vision defects (CVD) and ocular pathology (for example, congenital glaucoma or retinoblastoma). Colour vision assessment is, however, not always included in screening batteries, on the basis that congenital CVD is untreatable and that the role of impaired colour vision in the learning process has not yet been well-established. Screening for binocular vision dysfunction and hyperopia is better accepted as there is some evidence to support an association with impaired academic performance.

In 2009 an Australian group, under the auspices of the National Children’s Vision Screening Project (NCVSP), undertook a systematic literature review of the
effectiveness of vision screening programs. This literature review concluded that the
ideal age for screening the vision of children was between 18 months and 5 years, in
addition to a standard neonatal check. The review further concluded that screening
from ages 8 to 10 years old and from 13 to 15 years old was not indicated, as there was
insufficient incidence of previously unrecognised visual impairment in those age
groups. The NCVSP subsequently established an expert Project Advisory Group (PAG)
which recommended that vision assessment be undertaken at birth, between 3 and 6
months, and at four years of age (one year prior to school commencement). This
recommendation was made despite a lack of evidence found in the NCVSP literature
review to support vision screening of children aged 3 – 6 months. The PAG advocated
that screening of this age group was important to ensure that any vision problems
missed at the neonatal check could be detected. The PAG also recommended visual
screening at four years of age rather than from 18 months of age, as recommended by
the initial review, on the basis of the decreased ability of younger children to complete
the screening procedures effectively.

The NCVSP review concentrated only on vision screening programs that targeted
reduced visual acuity, strabismus, congenital cataract and congenital glaucoma.
However, conditions such as uncorrected hyperopia and binocular vision dysfunction
have been shown to have an association with reduced academic ability. These
visual conditions were not included in the NCVSP review which is a limitation to the
NCVSP’s final recommendations, as it can be argued that not all visual conditions
relevant to children were considered. Indeed, the optimal age group at which these
conditions would be detectable via vision screening may be different from those
recommended by the PAG.
Other authors have disagreed with the NCVSP’s recommendations regarding the optimal age for children to be screened. Whilst it has been suggested that improved visual acuity outcomes are achieved with earlier treatment of amblyopia, one study of children aged 7 years or less, reported that the age at which amblyopia treatment is instigated does not affect the final outcome for children within this age group. This suggests that the optimum age of treatment for amblyopia is not as critical as was previously believed. These findings add to the debate regarding the most effective age for screening children for amblyopia and its risk factors. It has also been suggested that while screening at preschool may detect amblyopia earlier, screening in the first year of school achieves a higher coverage because of compulsory school attendance, and provides a more time-efficient way to screen all children within a geographical region.

**Development of vision screening protocols**

The US-based Orinda study pioneered the systematic investigation of specific vision parameters that comprise an effective paediatric vision screening battery. This involved a three year study of primary school children from the Orinda School District in California, commencing in 1954. Eight screening methods were administered to school children, as well as a complete clinical eye examination. Optometrists and ophthalmologists from the Orinda study also identified a number of specific visual and ocular problems that should be prioritised for screening. These included reduced visual acuity, a range of refractive errors (hyperopia, myopia, astigmatism and anisometropia), binocular coordination disorders at distance and near (strabismus and significant heterophoria) and evidence of any ocular pathology.
What has since become known as the Modified Clinical Technique (MCT) provided the least number of under-referrals (highest sensitivity) and over-referrals (highest specificity). As such, it was the first vision screening protocol to be validated and is often considered to be the ‘gold standard’ paediatric screening protocol. Tests comprising the MCT are presented in Table 1. Table 2 further explains the statistical concepts of sensitivity, specificity and predictive values using the Ishihara colour vision test as an example; these metrics are commonly used to compare the effectiveness of individual tests or screening batteries.\textsuperscript{21}

The MCT had an 11.5% mean referral rate, compared with 5.8% mean referral rate based on visual acuity alone.\textsuperscript{1} In the Orinda study, the MCT battery correctly classified almost all children with extremely high sensitivity (98%), specificity (99%) and predictive values (positive predictive value of 0.90 and negative predictive value of 0.99). Distance visual acuity alone demonstrated poor sensitivity (27%) but relatively good specificity (99%) – and failed to identify many children who had vision problems, although it did not tend to result in over-referrals for those who had normal healthy eyes and good vision.\textsuperscript{1}

Including a test of refractive error (e.g. retinoscopy) markedly improved sensitivity compared with visual acuity screening on its own.\textsuperscript{22} Indeed, refractive errors such as hyperopia and some levels of astigmatism may be missed by visual acuity testing. In addition, screenings that only measure distance visual acuity have been criticised for not measuring visual function at near; arguably the visual skills that are most strongly related to reading and writing.\textsuperscript{4}
A disadvantage of the MCT is that it requires optometrists or ophthalmologists to assess refractive error (with retinoscopy) and to screen for ocular disorders; it therefore cannot be administered by non-ophthalmically trained vision screeners. Consequently, the expediency of the Orinda MCT as a screening tool has been questioned. Furthermore, the remarkably high sensitivity and specificity reported by the MCT from Orinda has not been replicated in subsequent studies that have also used the MCT battery. In two other studies the positive predictive values obtained were 0.69 and 0.52 – much lower than those found at Orinda. In the original Orinda MCT, the decision on whether a child passed or failed the MCT was based on assessments by two independent optometrists after consideration of the results from the series of tests. However, the opinion of an additional four vision care experts was sought in cases of disagreement. The lack of a definitive pass/fail criterion for the MCT in the Orinda study may explain why the extremely high sensitivity and specificity has not been replicated. Importantly, most vision screenings do not have the luxury of a sizeable “expert panel” to consult prior to making referral decisions.

A modified form of the Orinda MCT (Portsea MCT) was included in a vision screening project between 1980 and 1983 that was part of a larger public health initiative at Portsea in Victoria, Australia. Prior to this, from the late 1940s, optometrists had been performing ad hoc vision tests on approximately two thousand school children each year at this location. The Portsea MCT added fusional vergence, accommodative facility, ocular motility, stereopsis and colour vision tests to the Orinda battery, on the basis that these tests were more comprehensive in their measurement of visual parameters ostensibly associated with reduced school performance.
Even with the additional tests, the Portsea MCT could be performed within 5 – 6 minutes per child. Referral rates from the Portsea study were 17.7% (classified as “unsatisfactory”) and 10.4% (classified as “borderline”); this was comparable to referral rates from a NSW vision screening performed on a similar cross-section of children, as well as to other screenings that used the Orinda MCT at that time.

The NYSOA (New York State Optometric Association) screening battery was developed to identify children with a wider range of visual problems. The sensitivity and specificity of the NYSOA battery were 72% and 65% respectively. The NYSOA battery targeted reduced distance and near visual acuity, hyperopia greater than two dioptres, and problems with accommodative facility, near point of convergence, fusional reserves, colour vision, stereopsis, saccadic eye movements and visual motor integration. Unlike the Orinda MCT, the selection of tests included in the NYSOA battery allowed administration by non-ophthalmically trained screeners. However, it was more time consuming than the MCT; the Orinda MCT took between 5 – 6 minutes per child, compared with 15 minutes for the NYSOA battery.

The balance between sensitivity/specificity and time efficiency is important in developing an optimal screening battery. Increasing the number of tests in a vision screening battery involves a time penalty. It has, however, been shown that screening using visual acuity alone can miss up to 40% of children with potentially important vision problems – examples being hyperopia, binocular disorders or ocular disease.

Computerised vision screening programs

Computerised screening programs facilitate screening of a broad range of visual parameters in children. An example is the Visual Efficiency Rating (VERA), a
computer software program created for school nurses to screen for visual problems that can interfere with reading and school performance – namely, hyperopia, reduced visual acuity, binocular vision dysfunction, accommodation and ocular motility disorders. The VERA screening program takes approximately 12 - 15 minutes for each child, and was designed to maximise specificity. This was undertaken to alleviate the unwarranted anxiety for parents that is associated with over-referral, which may consequently result in pressure on schools to discontinue vision screening programs.

The sensitivity of the VERA was relatively low at 45% (i.e. 55% of the children who passed the screening battery were later determined to have visual problems), whilst the specificity was 83%. However, the sensitivity and specificity of the VERA improved when combined with a symptom survey (Convergence Insufficiency Symptom Survey), reading level, and a classroom behaviour survey (completed by a teacher). The authors concluded that the VERA is more accurate as a screening tool when targeting underachieving children – as determined by the classroom behaviour survey and a test of the child’s reading level.

Preschool screening programs

The effectiveness of the MCT, NYSOA and VERA has been evaluated for school children; however, the value of vision screening batteries in a preschool setting has not been reported. In 1997, the Vision in Preschoolers (VIP) study investigated eleven screening tests including three separate photoscreeners (Power Refractor II, MTI Photoscreener and iScreen Photoscreener), two autorefractors (Retinomax autorefractor and SureSight Vision Screener), two visual acuity tests (HOTV visual acuity, LEA symbols visual acuity), two stereoacuity tests (Random Dot ‘E’ stereoacuity, Stereo...
Smile II acuity), non-cycloplegic retinoscopy and the cover-uncover test. Only the latter two required trained personnel for administration.

Non-cycloplegic retinoscopy, Retinomax autorefraction, SureSight Vision Screener and the LEA symbols visual acuity test demonstrated the highest sensitivity for detecting children with amblyopia, strabismus, significant refractive error and/or unexplained reduced visual acuity. The VIP study used a set 90% specificity for most tests on the basis that this provided a level appropriate for screenings (10% over-referral rate). Both autorefractors were in the top three tests with regard to sensitivity (both at 63%) of all the VIP study’s tests. The autorefractors had the advantage of a short testing time, although are significantly more expensive than the Lea Symbols test, which showed equivalent sensitivity. Non-cycloplegic auto-refraction also has a tendency to over-minus when compared with non-cycloplegic retinoscopy, so there are disincentives to balance the positives in terms of time benefits. All three photoscreeners performed poorly in comparison with other tests.

The sensitivity and specificity of different vision screening protocols for detecting a range of visual conditions in paediatric populations are presented in Table 3, although it is important to understand that they cannot be compared directly as they were not all performed on children with identical age groups and socio-economic status.

**Vision screening programs currently in use in Australia**

Many different paediatric vision screening programs are currently operational in Australia although there is little coordination between states and territories, and a lack of consensus on how and when children should be screened. Each Australian state and territory has separate Health Department guidelines (Table 4). The terminologies
used in Table 4 are those employed within each set of guidelines; these differences and the overall absence of terminology definition further emphasises the lack of coordination between states and territories in regard to vision screenings. Nevertheless, amblyopia and strabismus are the focus of most protocols although risk factors for their development such as anisometropia and uncorrected hyperopia are largely overlooked. Many other relatively common visual conditions such as non-strabismic binocular vision disorders, refractive errors not affecting visual acuity, and ocular health problems are also absent from many of the state-based protocols.

The Healthy Kids Check (HKC) is a federal government sponsored health screening program administered within general medical practices. The HKC targets 4-year old children. The vision component nominally includes a general inspection of the external eyes, measurement of visual acuity (if age appropriate), and a brief history provided by a parent. It allows for referral to an optometrist in the event of concerns by the medical practitioner or nurse who administers the screening. Concerns regarding a lack of clear protocols for the assessors have been raised. In addition, there is a low rate of provision of the HKC and no data appears to be shared between or within jurisdictions. Thus, other providers of vision screening programs are not aware of which children have been previously screened as part of the HKC. Some private organisations also provide vision screening services to children. The Royal Flying Doctor Service assists with screening of regional Australian communities by nurses, and the Royal Institute for Deaf and Blind children screens over 1200 Aboriginal children per year. Vision screenings are conducted at some primary and secondary schools by local optometrists in an ad hoc manner that is likely driven by the
individual optometrist’s interest in paediatric vision and by their available time. As such, screening programs provided by optometrists in private practice result in an important but unmeasured and geographically inconsistent service provision in the community. This conclusion is supported by one of the findings of the NVCSP who identified very few studies that included optometrists in screening processes, despite the significant role they are assumed to play in this regard. As a result of the inconsistent distribution of screening resources in Australia, a co-ordinated, co-management system has been suggested – this strategy proposes that child and family health nurses, optometrists, orthoptists and GPs all play a role as primary screeners. Importantly, despite this recommendation by the NVCSP, little evidence has emerged to show that this is being implemented.

Vision screening programs in other countries

The debate regarding what is the most appropriate protocol for children’s vision screenings is not unique to Australia. In the USA, paediatric vision screening is more common and is incorporated in routine child health assessments and school health programs. Nonetheless, there is little agreement about when children should be screened, which conditions should be targeted, protocols that should be used and which screening personnel are best equipped to provide services – issues that are also relevant to Australia. For example, in Indiana all children are required to be screened with the MCT at enrolment to kindergarten or first grade, and receive additional visual acuity screenings in grades 3 and 8. In Illinois, school vision screening programs are mandated – with the Department of Public Health providing training and certification in vision screening to school nurses to facilitate compliance.
The Kentucky General Assembly in 2000 passed the first law in the US requiring children in the state of Kentucky aged 3 – 6 years to have a vision examination by an optometrist or an ophthalmologist before the child’s first year at a public school. In response to this mandate, the effectiveness of vision screenings conducted during school entrance physical examinations and comprehensive vision examinations performed in Kentucky were compared and indicated that comprehensive eye examinations detected problems not previously found by vision screenings. Three hundred children were diagnosed with eye problems, sixty six of which had undergone a previous vision screening. Despite these initiatives, results from the 2002 US National Health Interview Survey revealed that only 36.3% of children aged 5 years or younger had undergone a vision exam of any form.

In the United Kingdom (UK), the 1997 National Health Service (NHS) review suggested that preschool vision screenings may not be as beneficial as previously thought, arguing somewhat controversially that the conditions being targeted (amblyopia and refractive error) were “minor” problems, and that there was minimal evidence to demonstrate that treatment was beneficial.

Subsequent to the NHS review, a 2004 UK review by Logan and colleagues examined the evidence-base for the content, provision and efficacy of children’s vision screenings that specifically targeted refractive error, amblyopia, binocular vision and colour vision. In addition, the authors commented on the potential consequences of the curtailment of these screenings following publication of the 1997 review. As a result, they recommended children receive a vision screening between the age of 5 – 6 years (for detection of significant refractive error, colour vision and previously undetected amblyopia), as well as at the age of 11 years to assess for myopia development.
Despite major studies such as the Orinda, Portsea and VIP having broadened the scope of vision screening test content, vision screenings occur in many countries but distance visual acuity alone still forms the basis of these protocols, and other visual parameters are largely ignored. There remains a consequent risk of non-visual acuity related conditions remaining undetected. A summary of a number of screening programs conducted in other countries is provided in Table 5.46-49

The current review has demonstrated that there is no universally agreed policy or strategy for vision screening in children – either in Australia or internationally. This is likely a consequence of the paucity of evidence supporting the benefits of screening as well as inconsistent levels of support from relevant authorities and poorly co-ordinated and irregularly distributed service provision involving multiple health professions. Programs that are offered are not well-documented and data are rarely shared. Australian children stand to benefit from improved cohesion and communication between jurisdictions and health professionals to enable an equitable provision of validated vision screening services. Importantly, this provides the best chance of early detection and intervention for a range of paediatric visual problems.
References


23. Paech M. The Orinda Study: should the 'Modified Clinical Technique' retain its 'gold standard' status as a vision screening tool? Clinical and Experimental Optometry 2010;93:31-6.


