School vision and hearing screening enters the 21st century

School Screener is a new computer-based solution for managing screening in schools. **Professor David Thomson** gives an overview of the system and the evidence for its effectiveness

'Can you read the letters on the chart?' I inquired of the five-year-old. The rather blank look and shake of her head suggested she could not. 'What about these larger letters?' Still no response. Eventually, with some difficulty she read the letters on the logMAR 0.5 (6/19) row.

This child was one of approximately 18 per cent of five-year-olds who have poor vision in one or both eyes. Neither the child, her teacher nor her parents were apparently aware that her vision was poor and, without school vision screening, it is likely to have been several years before the problem would have been detected. While it is difficult to predict exactly what effect this may have had on her social and educational development, there is little doubt that it would have been detrimental to some degree.

Three weeks later her mother reported that she was proudly wearing her new glasses and already interacting more in the classroom and showing increased enthusiasm for reading.

Learning has been defined as the 'acquisition of understanding through the senses'. While all of the senses are important conduits of information, vision and hearing are particularly important in this respect.

The importance of good vision during the formative years led to the introduction of routine vision screening in schools in the UK over 100 years ago. While the school screening programme has been less than perfect, there is no doubt that it has provided a useful safety net, detecting children with significant vision problems at an early stage before their educational development was affected.

General policy on vision screening is set by the National Screening Committee (NSC) and guidance is provided in a related publication known as 'Health for all children'.[1] In 2003, the NSC recommended that vision screening was limited to a single screening on school entry at the age of 4-5 years and that screening at the age of seven and 11 should cease.

While some localities have implemented good screening programmes, surveys carried out by the RNIB[2] and *Which?*[3] suggest that many authorities have no screening programme in place at all. Even where screening programmes are in place, in many cases the programmes lack proper mechanisms for audit or adequate pathways to manage the children who 'fail' the screening.

Since 1995, a team from City University London has been investigating ways of improving the sensitivity, specificity, efficiency and cost-effectiveness of screening in schools. One of the outcomes of this work is a computer system known as the School Screener. This system offers a radical new solution for providing an efficient and effective vision and hearing screening programme.

This article gives a brief overview of the School Screener system and the evidence for its effectiveness. The article is focused on vision screening although the system can also be used for hearing screening and collecting height and weight data.

Target conditions for vision screening

The first few years of life are a time of radical development for the human visual system. While the eyes themselves are fully formed at birth, the complex network of cells in the brain which interprets the information received from the eyes is immature. As a result, a new-born infant has very limited visual perception.[4]

The brain matures rapidly over the first few months of life and by the age of one year most attributes of vision are present, although the visual system does not reach full maturity until the age of approximately seven years.

Any obstacle to vision during this critical period, including refractive errors and strabismus, impacts on visual development and may lead to amblyopia. If amblyopia is detected before the age of approximately seven, vision in the amblyopic eye can often be improved by prescribing spectacles and/or patching the good eye for a few hours each day. Treatment becomes less effective after the age of seven as the brain loses its plasticity.

Another challenge for the developing eye is the change in focal length as the eye grows. In order to keep the image in focus on the retina as the focal length of the eye changes, the shape of the cornea has to change in exact proportion. This process, known as emmetropisation, works well in most cases and the majority of children retain good focus throughout the growth period. However, in some cases the process fails and this results in the child developing a refractive error.

Much of the debate relating to school screening has concentrated on the value of detecting and treating amblyopia and barely considered the impact of uncorrected refractive errors.

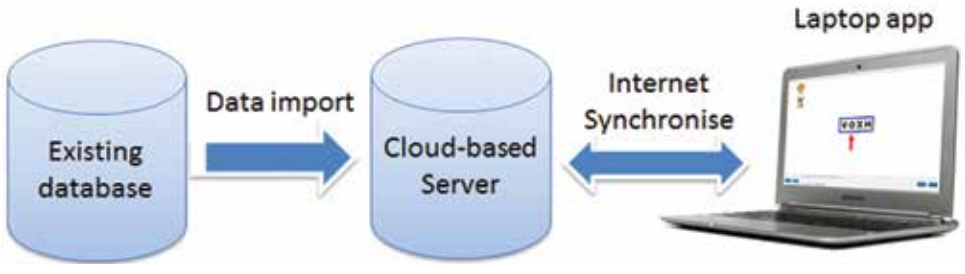


Figure 1 Before screening, the laptop is synchronised with the server to include all the relevant information, including a list of the children to be screened

Figure 2 Each child is selected from the list and the their hearing or vision screening may begin

Indeed, a recent review commissioned by the National Screening Committee on which revised guidance on school screening will be based, is entirely focused on amblyopia with refractive error effectively dismissed as a target condition.[5] This is somewhat surprising given that uncorrected errors are far more common than amblyopia, are probably more detrimental to a child's educational and social development and are usually completely remediable at a fraction of the cost of treating amblyopia. Indeed, given that amblyopia therapy has minimal effect on a child's overall binocular function or ability to perform everyday tasks, the case for detecting and treating amblyopia hinges primarily on improving the visual prognosis if the vision in the good eye is impaired through trauma or disease. The number of amblyopes suffering such a fate is relatively small and given the costs associated with screening therapy,[5] amblyopia barely makes the grade as a target condition.

The low priority given to refractive errors in this debate is probably attributable to a number of factors. While common sense (and simple optics) dictates that refractive errors will make many tasks in the classroom more difficult to perform, there is a lack of good quality evidence in the literature relating refractive errors to educational development. This is not all that surprising given that even if a randomised controlled study to look at this relationship could obtain ethical approval, the huge number of factors affecting a child's educational development would make it extremely difficult to tease out the real effects of blurred vision. The problem with a slavish adherence to evidence-based practice is that lack of good quality evidence is often taken as evidence that there is no effect, even when common sense and anecdotal evidence suggests otherwise. A second reason for the low priority given to refractive errors is that it is still not considered as a 'proper visual impairment' in some circles. It is interesting in this respect to note that the World Health Organization's definition of visual impairment is now based on 'presenting visual acuity' in recognition of the fact that uncorrected refractive error is just as debilitating as other types of poor vision.[6] A child with a significant uncorrected refractive error is indeed visually impaired until they are corrected.

Fortunately, current guidance for school screening is based on the detection of reduced monocular acuity which will detect children with significant myopia and astigmatism as well as the amblyopia. However, children with hypermetropia often have normal visual acuity and will therefore pass the screening. The addition of a +2.50 blur test adds approximately one minute to the screening and has been shown to be an effective way of detecting those with significant hyermetropia (>+2.00). While not all children with hypermetropia in this range will require correction, it is at least arguable that they should be examined and monitored.

Therefore, the primary target conditions for vision screening are amblyopia and significant refractive error. While there are many other problems and conditions that can affect a child's eyes, they are not common enough or serious enough to justify being included as target conditions for universal screening.

School Screener software

The School Screener system consists of software which runs on a standard laptop (running Windows XP or later) and a secure cloud-based server. The software is fully compliant with NHS information governance standards.

A screening cycle begins by uploading a list of the children to be screened. It is recognised that these lists are subject to change and children can be added or removed from the list at any stage throughout the year.

Each School Screener is then registered on the system and required to generate a password. Screeners can be allocated to all the schools in the locality or a subset.

Before attending a school, the screener synchronises the laptop software with the server by simply connecting to the internet and clicking on Sync. This downloads a list of all the children at the schools that the screener has been allocated. This information is stored locally so that internet access is not required when the screener visits the school (Figure 1).

Screening

The screener then visits the school and sets up the laptop in a suitable room. As each child is called, the screener simply selects the child's name from the list and selects vision or hearing screening (Figure 2).

For vision screening, a cartoon character gives the child exact instructions about when to cover each eye and put on the 'special' glasses. Instructions can be spoken in 27 different languages or muted so that the screener gives the instructions. The software uses the gold standard tests for vision screening as recommended by the NSC. Visual acuity is measured

with the child standing at three metres from the laptop screen and viewing letters displayed in a crowded LogMAR format (Figure 3). Displaying the letters on a laptop screen rather than using printed charts provides better control over the luminance and contrast of the charts and allows the letter size to be scaled to accommodate different viewing distances. Matching cards may be used with children who are not yet able to name letters.

To progress the test, the screener simply clicks on the Next button using the mouse or uses the wireless remote control. For the visual acuity test, letter size is varied automatically according to the recommended protocol and all scoring and recording of results happens automatically. A vision screening can usually be completed in less than three minutes.

For hearing screening, an audiometer device (the size of a spectacle case), developed specifically for the system, is plugged into the laptop. This device is used to generate test tones under computer-control through the calibrated headphones. The child is seated in front of the laptop screen and watches three cartoon characters appear on the screen. The child is asked to report which of the characters 'squeaks'. The tones are presented to each ear at the predetermined frequencies and following the recommended protocols.

For height and weight screening, the measurements are simply entered into the system. The software automatically determines the BMI and the corresponding centile for a child of the corresponding gender and age and places the child into one of four categories: under-weight, healthy weight, over-weight or obese. Personalised letters with appropriate wording can then be generated automatically and the final data set exported to a spreadsheet for submission to the National Child Measurement Programme.

The tests are usually very well received by the children who are often so absorbed in the 'game' they do not realise they are being screened. The results are all securely stored on the laptop, removing the risks associated with paper-based records.

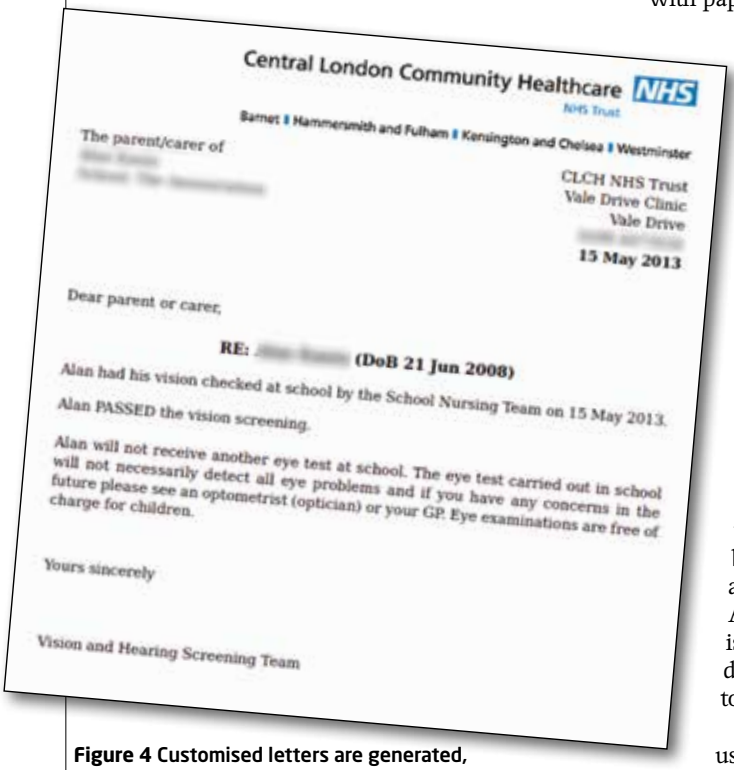
Figure 3 Visual acuity is measured with the child standing at 3m from the screen and viewing letters displayed in a crowded logMAR format

Letter generation

On completion of the screening the laptop is once again connected to the internet and with the click of a button, the results are synced with the server. The server then automatically analyses the results and generates personalised letters for the parents or carers of each child. The letters follow templates which are customised for each locality (Figure 4).

The screener or an administrator can then log in to the server using a standard browser and print the reports at the click of a button. Alternatively, a printing service is available so that letters are delivered to each school, ready to be handed to the child's carer.

Thus, a task which often used to take days, is achieved in seconds.



Central London Community Healthcare NHS
NHS Trust
Barnet | Hammersmith and Fulham | Kensington and Chelsea | Westminster

The parent/carer of
[redacted]

CLCH NHS Trust
Vale Drive Clinic
Vale Drive
[redacted]
15 May 2013

Dear parent or carer,

RE: [redacted] (DoB 21 Jun 2008)

Alan had his vision checked at school by the School Nursing Team on 15 May 2013.

Alan PASSED the vision screening.

Alan will not receive another eye test at school. The eye test carried out in school will not necessarily detect all eye problems and if you have any concerns in the future please see an optometrist (optician) or your GP. Eye examinations are free of charge for children.

Yours sincerely

Vision and Hearing Screening Team

Figure 4 Customised letters are generated, specific to each locality

Referral pathways

Screening on its own is of little inherent value without a robust pathway to ensure that those with vision or hearing problems receive the appropriate treatment or intervention. In the past, following children through the referral pathway has been a time-consuming and difficult process, requiring the transfer of referral letters to the secondary clinic and the return of examination reports/tear-off slips. In practice, most authorities do not track children beyond the initial letter to parents and therefore have no way of ensuring that those who test positive receive the tests and intervention they may require.

The School Screener provides an elegant and efficient solution to this problem. Parents of children who test positive at the screening receive letters giving clear and precise instructions about how to book the secondary examination. For vision screening, the examination might be with an optometrist, a secondary clinic or a hospital, depending on the local policy.

When the child attends the secondary clinic, the clinician can log in to the server using a secure code and view the results of the screening and any comments recorded by the screener (Figure 5). They are also asked to record if the screening result was correct (true positive), ie did the child turn out to have one of the target conditions? They may also record additional clinical information such as visual acuity, spectacle prescription and treatment/intervention prescribed.

Thus, at any moment in time, the system can provide information on the number of children screened, the number who have tested positive, the number of screen positives who have attended for a secondary examination and the number of these children who were true positives. This powerful audit information allows the programme director to constantly monitor the progress and effectiveness of the overall screening programme. Issues with over- or under-referral rates can be readily identified and appropriate measures taken.

While most parents and carers tend to comply with the initial request to arrange a secondary examination, a minority often require further encouragement. To address this issue, an automated reminder protocol can be set up so that the School Screener automatically generates reminder letters for all children who test positive but have not yet attended the secondary clinic. Up to three reminder letters

can be sent at prescribed intervals following the screening.

Does it work?

The system was first developed over 10 years ago and has been subject to extensive clinical and field trials. In a clinical trial involving over 3,000 children in inner-London schools, all children were screened using the system and then examined by an optometrist and an orthoptist. Using the outcome of the clinical assessment as the 'gold standard', the program was found to have a sensitivity of 96.9 per cent and a specificity of 96.1 per cent, ie the program correctly identified 96.9 per cent of the children with the target conditions and 96.1 per cent of the children with 'normal' vision.[7]

The children responded very well to the screening tests, perceiving the whole process as a 'computer game'. The personalised reports generated for the parents and carers of the children were also very well received. With appropriate organisation within the schools it was possible to screen between 10 and 15 children per hour using a single computer.

Since large-scale pilots ended in March 2013 areas covering more than 30,000 children have started screening using the new system and many more areas are in discussions to start using it either later in 2013 or early 2014. In the pilots, overall, 18 per cent 'failed' the vision screening. Of these, approximately 10 per cent of those who have received secondary tests were false positives, 17 per cent required treatment for amblyopia and the remainder (73 per cent) had a refractive error. Sixty-two per cent of those tested were given spectacles.

Summary

School vision screening is not a substitute for a full eye examination – it will not detect all eye problems and does not attempt to diagnose or manage the causes of poor vision. Some have argued that a better approach would be to encourage parents to give children's eye care a higher priority and ensure that their children receive regular eye examinations. However, the current reality is that a large proportion of children have never had an eye examination. Public health strategists would also argue that given the relatively low prevalence of significant eye problems among children in developed countries, the case for universal eye examinations is weak.

School vision screening has the potential advantage of reaching close to 100 per cent of children and if carried out well, provides a useful safety net for the early detection of vision problems. Given that the majority of children who 'fail' the vision screening will have refractive errors, optometrists could and should play a prominent role in the secondary management of these children.

The School Screener provides a radical new solution for managing screening in schools. The system oversees the entire process including obtaining parental consent, testing vision and hearing, generating letters and reports, tracking through the referral pathway and collating audit statistics.

It is hoped that the National Screening Committee will recognise that the benefits of school screening extend beyond the detection of amblyopia and will reaffirm or indeed strengthen their support for a national screening programme.

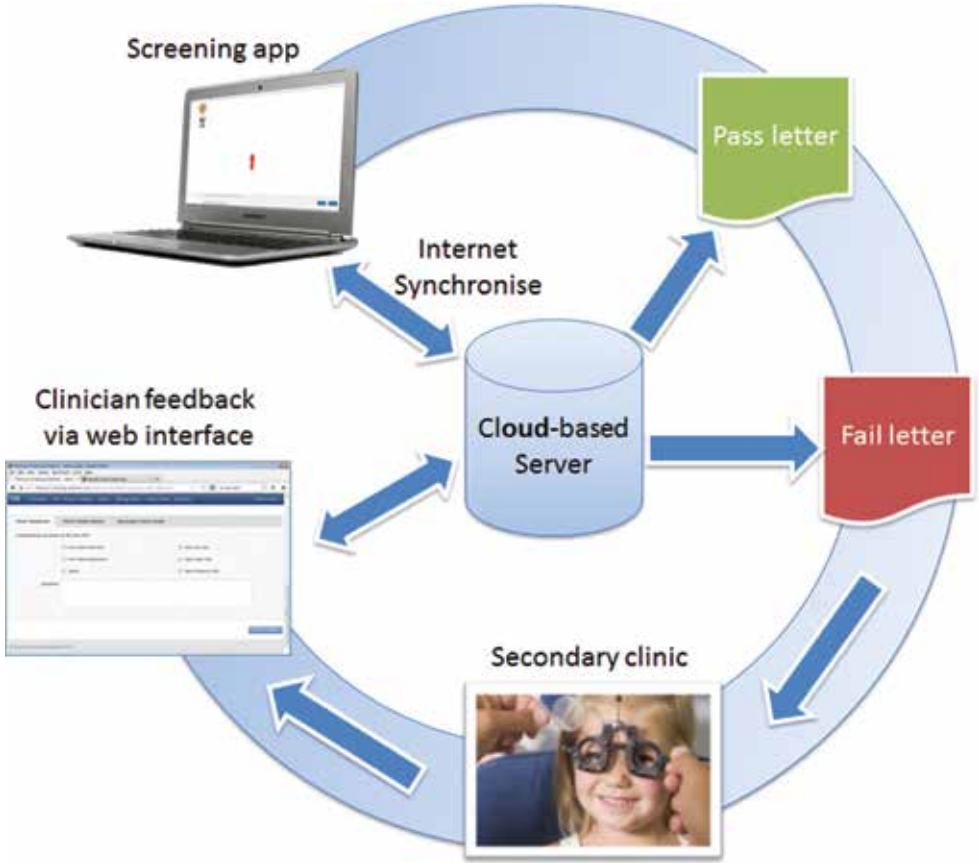


Figure 5 The powerful audit information allows any child's progress to be monitored

References

1 Hall D and Elliman D. *Health for all children*. 2003. Fourth ed. Oxford: Oxford University Press.

2 McLaughlin B. 2009. *Screening children's eyes*. Study finds gaps in provision. [Online] Available at: www.vision2020uk.org.uk/core_files/What'snewchildren.doc [Accessed 12 August 2013].

3 Pearl J. *Schools, open your eyes and offer kids eye tests*. 2011. [Online] Available at: http://conversation.which.co.uk/consumer-rights/child-vision-screening-eyesight-school-primary-care-trusts/ [Accessed 12 August 2013].

4 Daw N. 2006. *Visual development*. Second ed. New York: Springer Science.

5 Solebo A. *Vision screening in children aged 4-5 years*. 2013. Retrieved August 12, 2013, from NSC Screening Portal: www.screening.nhs.uk/vision-child.

6 World Health Organization (2012, June). *Visual impairment and blindness*. Retrieved August 2013, from World Health Organization: www.who.int/mediacentre/factsheets/fs282/en/

7 Thomson W D and Evans B. A new approach to vision screening in schools. *Ophthalmic Physiol Opt*, 1999; 19(3), pp 196-209.

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