Preschool vision screening: negative predictive value for amblyopia

Douglas K Newman, Miranda M East

Abstract

Background/aims—Single optotype tests of visual acuity are widely used for preschool vision screening in order to optimise cooperation with testing. These tests may, however, underestimate the visual acuity deficit in amblyopia because they lack visual crowding. This study assessed the resultant negative predictive value (NPV) for amblyopia.

Methods—Cohort study of 936 children in the Cambridge Health District selected by date of birth. The presence of amblyopia among children who had passed preschool vision screening was determined using Snellen line acuity as the reference test. Preschool vision screening was conducted at 3.5 years of age by community orthoptists. The screening assessment comprised Sheridan–Gardiner single optotype test of visual acuity (referral criterion 6/9 or worse in either eye), cover test, ocular movements, 20° prism test, and TNO stereotest.

Results—The overall NPV of preschool vision screening for amblyopia was 100% (95% CI 99.4% to 100%). Most children with amblyopia were detected by the Sheridan–Gardiner single optotype test of visual acuity, but the other screening tests were necessary to prevent any false negatives. In isolation, the Sheridan–Gardiner single optotype test of visual acuity has a NPV for amblyopia of only 99.6% (95% CI 99.4% to 100%).

Conclusion—Preschool vision screening using a single optotype test of visual acuity does achieve a high NPV for amblyopia, but only under certain conditions. These comprise a low threshold for referral (6/9 or worse in either eye) and the inclusion of a cover test and tests of binocular function in the screening assessment.

Preschool vision screening aims to detect children with unsuspected amblyopia at a young age during the sensitive period for treatment. Visual acuity assessment is currently the most effective screening test for amblyopia. Consequently, preschool vision screening is generally conducted at around 3.5 years of age because this is the youngest age at which monocular visual acuity can be reliably assessed in the majority of children.

Single optotype tests of visual acuity, such as the Sheridan–Gardiner chart, are widely used for preschool vision screening in order to optimise cooperation with testing. These tests may, however, underestimate the visual acuity deficit in amblyopia because they lack visual crowding. In an attempt to prevent any children with amblyopia being missed by screening, a low threshold for referral (6/9 or worse in either eye) is generally adopted. Other components of the screening assessment, such as the cover test and tests of binocular function, may also help to reduce the risk of amblyopic children being missed by screening.

Children also undergo vision screening on school entry at 5–6 years of age. Visual acuity can be assessed at this age with linear optotype tests which allow greater accuracy in the detection of amblyopia. Debate continues regarding the relative merits of preschool vision screening and vision screening at school entry for the detection and treatment of amblyopia since there are no controlled comparative studies. The negative predictive value (NPV) for amblyopia is an important determinant of the relative efficacy of these screening options, but has received little attention to date. This study therefore assessed the NPV of preschool vision screening using a single optotype test of visual acuity.

Methods

A retrospective cohort study was conducted of children resident in the Cambridge Health District during 1995 with a date of birth in the 4 month period September to December 1986. These children were identified from the Community Child Health Service database which has a coverage of approximately 98%. The population of the Cambridge Health District was 271 000. The preschool vision screening status of children in the cohort was determined by reviewing their community child health records.

Preschool vision screening is offered to all children in the Cambridge Health District at 3.5 years of age. The screening assessment (Table 1) is performed by an orthoptist in a community setting. The criteria for referral to the hospital eye service (HES) for further assessment are: (1) visual acuity 6/9 or worse in either eye, (2) manifest strabismus, (3) decompensating heterophoria, (4) abnormality of ocular movements, (5) abnormal response to 20° base out prism test, (6) negative response to Sheridan–Gardiner single optotype chart at 6 metres (%).
to TNO screening plate, or (7) any other ocular abnormality. In the presence of equivocal findings, children are recalled for another screening assessment by the community orthoptist.

The presence of amblyopia among children who had passed preschool vision screening was determined using Snellen line acuity as the reference test. Snellen line acuity was determined by reviewing the result of each child’s school entry vision test at 5.5 years of age. If a Snellen line acuity of 6/6 in each eye had not been documented, the child was recalled for another visual acuity assessment. Amblyopia was defined as a best corrected Snellen line acuity of 6/12 or worse in either eye and/or an interocular difference of two Snellen lines or more.

The school entry vision test is conducted at 5.5 years of age in all maintained schools in the Cambridge Health District. Children in the cohort were therefore eligible for this test during the summer term of 1992. Visual acuity is assessed by a school nurse using a full Snellen chart at 6 metres, with spectacle correction if worn. A Stycar single optotype test is employed for children unable to perform Snellen chart testing. Children found to have defective vision (and those unable to cooperate with Snellen line acuity testing) were generally retested by the school nurse on a subsequent occasion. Children with confirmed defective vision are referred, at the discretion of the school nurse, to either an optometrist or the HES.

The exact limits for the 95% confidence interval (CI) of the NPV for amblyopia were calculated using the binomial distribution.

Results

There were 936 children in the selected cohort. The community child health records were reviewed for 95.9% (898/936) of these children. Of the remaining 38 children, 30 had left the Cambridge Health District and eight children were recalled for another screening assessment by the community orthoptist. Snellen line acuity was determined using Snellen line acuity as the reference test. Snellen line acuity was determined using Snellen line acuity as the reference test. Snellen line acuity was determined using Snellen line acuity as the reference test.

Table 2 Preschool vision screening status of children

<table>
<thead>
<tr>
<th>Preschool vision screening status</th>
<th>No (%) children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attended screening, passed</td>
<td>542 (60.4)</td>
</tr>
<tr>
<td>Attended screening, referred to HES*</td>
<td>59 (6.1)</td>
</tr>
<tr>
<td>Defaulted screening</td>
<td>157 (17.5)</td>
</tr>
<tr>
<td>Already attending HES at age of screening</td>
<td>18 (2.0)</td>
</tr>
<tr>
<td>Unknown</td>
<td>126 (14.0)</td>
</tr>
</tbody>
</table>

*HES=hospital eye service.

Table 3 Children with amblyopia who were not identified at preschool vision screening by the Sheridan–Gardiner single optotype test of visual acuity

<table>
<thead>
<tr>
<th>Child</th>
<th>Reason for failing preschool vision screening</th>
<th>HES findings</th>
<th>Snellen line acuity*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Decompensating exophoria + negative stereopsis</td>
<td>Anisometropic amblyopia</td>
<td>6/9 6/5</td>
</tr>
<tr>
<td>2</td>
<td>Decompensating exophoria + poor motor fusion</td>
<td>Unilateral posterior polar cataract with amblyopia</td>
<td>6/12 6/6</td>
</tr>
</tbody>
</table>

*Unaided Snellen line acuity recorded at HES before occlusion therapy was commenced. In both cases, the unaided visual acuity at preschool vision screening was 6/6 in each eye with a Sheridan–Gardiner single optotype test.

Discussion

In this study, the NPV of preschool vision screening for amblyopia was 100% (95% CI 99.4% to 100%). The most effective screening test for the detection of amblyopia was visual acuity assessment, as reported previously. However, single optotype tests of visual acuity, even with a low threshold for referral (6/9 or worse in either eye), did not detect every child with amblyopia. Two of the 15 amblyopic children detected by preschool vision screening in...
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This study were referred because of a decompen-
sating heterophoria with reduced binocular
function. Screening by visual acuity assessment
alone would have resulted in a NPV for
amblyopia of only 99.6% (95% CI 98.7% to
99.9%). While other screening tests contribute
relatively little to the overall detection of
amblyopia, they are necessary to minimise the
risk of amblyopic children being missed by
preschool vision screening.

The design of this study did not allow the
NPV of preschool vision screening for its other
main target conditions, strabismus and high
refractive error, to be determined. Ocular
alignment is not assessed in the school entry
vision test. It is, however, unlikely that any chil-
dren with strabismus were missed by preschool
screening since ocular alignment was assessed by
an orthoptist using the cover test. Refractive
errors (as judged by wearing of spectacles)
were present in six of the 542 children who had
previously passed preschool vision screening. It
is possible that these children had reduced
vision due to uncorrected refractive errors at
3.5 years of age which was not detected at
screening. Single optotype tests may certainly
underestimate visual acuity deficits in the pres-
ence of uncorrected low refractive errors. However,
these children may equally have developed refractive errors sufficient to reduce
visual acuity after passing preschool vision
screening.

There are some potential limitations in
interpreting the results of this study. Firstly,
Snellen line acuity was assessed by a retrospec-
tive analysis of testing performed by school
nurses. This assessment was not performed
under strictly standardised conditions, unlike
preschool vision screening, with some conse-
quent variability in Snellen chart design and
testing conditions. Ascertainment of screening
negatives should not, however, have been
significantly impaired since visual acuity test-
ing in schools tends to be performed under
suboptimal conditions with consequent under-
estimation, rather than overestimation, of
visual acuity. Secondly, a Snellen line acuity
was not available for one of the 542 children
who had previously passed screening (his best
recorded visual acuity was 6/6 in each eye with
a single optotype test). Amblyopia cannot be
definitely excluded for this child which, if
present, would reduce the NPV of preschool
vision screening to 99.8% (95% CI 99.0% to
100%). Thirdly, this study makes the assump-
tion that no child was detected and treated for
amblyopia in the 2 year interval between pass-
ing preschool vision screening and attending the
school entry vision test. There is, however,
no reason to doubt the validity of this assump-
tion.

Few other studies have assessed the NPV of
preschool vision screening using a single opto-
type test of visual acuity. In one Swedish
study, visual acuity was assessed at 4 years of
age with Marquez–Boström’s hooks (a modifi-
cation of the Landolt C optotype) on linear acuity test-
ing at 7 years of age. Calculations based on
the results reported in this study give a NPV for
amblyopia of 99.9% (95% CI 99.6% to
100%), which is similar to our result. The find-
ings of the other two studies are limited by
inadequate ascertainment of screening false
negatives and use of a single optotype test of
visual acuity as the reference test for
amblyopia.

There have also been some reports of the
NPV of preschool vision screening using a lin-
ear optotype test of visual acuity. One study
assessed a screening programme in Cornwall
which comprised a full orthoptic assessment
that was otherwise almost identical to our
study. It reported a 95% CI for the NPV for
any target condition (amblyopia, refractive
error or strabismus) in two separate study
cohorts to be 99.12% to 99.25% and 99.46%
to 99.54%, respectively. These values are lower
than our result, most probably due to the
inclusion of refractive errors that developed
after screening. Another study reported a NPV
of 98.7% (95% CI 95.4% to 99.9%) for any
target condition in a screening programme
that comprised assessment of only visual acuity and
stereoacuity. The findings of one further
study are limited by inadequate ascertainment
of screening false negatives.

In addition to a high NPV, preschool vision
screening should also have an acceptable posi-
tive predictive value (PPV). For the Cambridge
Health District screening programme, a PPV
of 79.9% (95% CI 75.0% to 84.3%) for the
detection of any target condition (amblyopia,
refractive error or strabismus) has previously
been reported. Studies of other comparable,
orthoptist based screening programmes have
reported values ranging from 74% to
94%. Apparently reduced vision is by far
the most common reason for false positive
referrals because of the low threshold for refer-
ral (6/9 or worse in either eye). This low
threshold is necessary to prevent a significant
proportion of children with amblyopia from
being missed, but does not preclude a high
PPV. An acceptable PPV is, however, only
achieved when screening is performed by
orthoptists, which reflects the expertise re-
quired to assess vision and ocular alignment
accurately in young children.

A recent systematic review concluded that
there is little evidence to support the proposed
benefits of preschool vision screening. The
current study provides evidence that the
efficacy of amblyopia detection by preschool
vision screening is equivalent to vision screen-
ing at school entry. Preschool vision screening
with a single optotype test of visual acuity
achieves a high NPV for amblyopia, provided
tests of ocular alignment (cover test) and
binocular function (20/20 prism test and stereo-
acuity tests) are also included. Another ap-
proach may be to use “crowded” optotype tests
of visual acuity which are suitable for preschool
children.
to have greater sensitivity in detecting amblyopia, further validation studies are needed before they can be adopted for preschool vision screening. Justification of preschool vision screening, however, still awaits the demonstration that earlier detection of amblyopia improves the visual outcome compared with vision screening at school entry.

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2 Egan DF, Brown R. Vision testing of young children in the age range 18 months to 4 1⁄2 years. Child Care Health Dev 1984;10:381–90.
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