EXTENDED REPORT

Amblyopia treatment outcomes after preschool screening v school entry screening: observational data from a prospective cohort study

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Background/aims: Preschool screening for amblyopia has controversially been abandoned in some localities within the United Kingdom, on the basis that there is no clear evidence of benefit to support its continuation. Data collected within a birth cohort study were used to examine visual outcomes at 7½ years in children who did or did not receive preschool vision screening.

Methods: Monocular logMAR visual acuity with and without a pinhole was assessed by orthoptists. Contemporary records were used to identify children who had been offered and/or received preschool screening.

Results: Of 6081 children, 24.9% had been offered preschool screening and 16.7% had attended. The prevalence of amblyopia was approximately 45% lower in the children who received preschool screening than in those who did not (1.1% v 2.0%, $p = 0.05$). The mean acuity in the worse seeing eyes after patching treatment was better for amblyopic children who received preschool screening than for those who did not; 0.14 v 0.20 logMAR ($p < 0.001$). These effects did not persist in an intention to screen analysis.

Conclusions: Preschool screening at 37 months was associated with an improved treatment outcome for individuals with amblyopia. However, the improvement was clinically small and disappeared when considering all children offered screening rather than only those who received it. Further research is needed into improving the effectiveness of vision screening for preschool children, while in the interim these data do not conflict with current recommendations for school entry screening by orthoptists.

Preschool vision screening services were set up in order to detect amblyopia as early as possible. It was believed that the experimental data from animals showing decreasing responsiveness to treatment for visual disorders with increasing age¹ applied also to human visual development. More recently, a systematic review from the NHS Centre for Reviews and Dissemination summarised the available clinical evidence and emphasised that there was no evidence from methodologically sound studies to suggest that preschool screening was effective in reducing the population burden of amblyopia.² The review recommended that “providers currently offering screening programmes should consider discontinuing them” and this has led to discussion about the future of preschool screening services.^{3–5} The UK National Screening Committee is considering proposals from an advisory subgroup that all 4–5 year olds have vision screening by an orthoptist at school entry, as an interim measure pending further evidence.⁶

One key issue to be resolved is whether treatment for amblyopia is more effective when given earlier in the child's life or course of the disease, or whether age at treatment makes no difference (in which case screening preschool children is unnecessary). Existing data from retrospective studies have produced conflicting results regarding the importance of age at treatment; either that age at treatment is^{7–9} or is not^{10, 11} relevant to the final outcome. We have recently presented data from a randomised controlled trial (RCT) in which an experimental, intensive vision screening programme offered before 37 months of age resulted in 67% fewer children with amblyopia at 7½ years and better vision in those treated for amblyopia, than did vision screening at 37 months.¹² The present paper presents data on the outcome at age 7½ for children who received an existing, single sweep orthoptic

screening programme at 37 months, compared with those who did not. Both the RCT and the present study are part of an ongoing birth cohort study.

METHODS

Setting and participants

The Avon Longitudinal Study of Parents and Children (ALSPAC or “Children of the Nineties”) project is a longitudinal study following the health and development of children born in a geographically defined area (which was formerly Avon), between 1 April 1991 and 31 December 1992. Approximately 14 000 children were recruited, an estimated 85% of those eligible.^{13, 14} Since the age of 7½, all participating children have been invited to yearly examination sessions where a variety of collaborators from different disciplines have assessed them. This paper uses data from all children who attended the examination at the age of 7½ years and who were part of a “natural experiment,” in which children from some districts in the study area were offered screening at 37 months, whereas children from other districts were not. Data are not presented for a randomly selected subgroup, who were involved in the RCT and whose results are presented separately.^{12, 15}

Vision screening services in the study area

One of the three health districts in the ALSPAC study area provides preschool orthoptic vision screening; the others do not. One institution provides hospital eye services (HES) for the whole study area. The HES clinic lists for the preschool vision screening clinics in the relevant years were copied, stripped of identifiers except for a code number, and linked with the main ALSPAC database. These clinic lists identified

children as having been offered preschool screening and also noted whether they had attended or not.

The orthoptic preschool screening examination includes a monocular vision test (Kay's pictures or Sheridan Gardiner singles), a cover test, and an assessment of binocularity using a 20 dioptre prism or a test of stereopsis, or both. Failure of any part of this examination results in referral to the HES, after a retest if poor cooperation is suspected. All children in the study area are offered vision screening in the school reception class (age 4–5 years).

Outcome data

Vision testing at 7½ was carried out by orthoptists who had not been involved in the preschool screening clinics and were unaware of the child's screening history. They tested monocular logMAR acuity with ETDRS charts, using a standardised protocol and giving credit for each letter identified correctly. Children were tested in their "habitual" state (that is, with spectacles if worn) and in the state of "habitual plus pinhole," the latter as a proxy for full refractive correction with spectacles. Autorefraction and a cover test were also carried out. A randomly selected 3% of all children attending were invited back within 6 weeks for a repeat examination, for which the testers had no records of their previous visit, to provide quality control data.

Any child with a strabismus or visual acuity in either eye of 0.2 or worse (approximately 6/9 or worse on a Snellen chart) was invited to a separate research clinic where an experienced optometrist checked their refraction under cycloplegia and examined their fundi.

Power of the study and statistical methods

The primary outcomes were the prevalence of amblyopia at 7½ years and the results of treatment for amblyopia (visual acuity in the worse seeing eye), in children who had actually received orthoptic preschool vision screening, compared with the children who had not. Further comparisons were carried out comparing those children who were offered orthoptic preschool vision screening with those who weren't (intention to screen approach). Calculated post hoc, the numbers of children who provided outcome data (of whom approximately one sixth actually attended the preschool vision screening clinics) gave this study 80% power (using a two tailed $p < 0.05$) to detect a drop in the prevalence of amblyopia of 62.5%—for example, from 2.0% down to 0.75%, with a corresponding odds ratio of approximately 0.35.

The visual acuity of each eye was taken as the better of "habitual" v "habitual plus pinhole." Proportions were compared using the χ^2 test or Fisher's exact test. Amblyopia was initially defined in advance in two ways, to allow comparisons with other studies; amblyopia A, where the interocular difference in acuity was 0.2 logMAR (two lines on the chart) or more,¹⁶ and amblyopia B—where the visual acuity in the amblyopic eye was worse than 0.3 logMAR (worse than 6/12).^{17,18} In order to allow a further post hoc direct comparison with a previous study of similar design,¹⁹ a definition of "6/9 or worse in one eye" (0.18 or worse logMAR) was also used—amblyopia C.

Continuous data were compared using analysis of variance or multivariate regression provided the data approximated to a normal distribution and Mann-Whitney if they did not. Data on potential confounding variables were taken from the main ALSPAC database. Results are proportions (95% CI), intraclass correlation coefficients (ICC, 95% CI), odds ratios (OR, 95% CI), or mean (SD) or median (interquartile range) visual acuities in logMAR units, unless otherwise stated.

Quality control for visual acuity data

All results are for the right eyes (very similar results were obtained for the left eyes).

The randomly selected 3% of children who were invited a second time provided the data used to estimate test and tester variability. There was a small learning effect in that on average, children who were retested did very slightly better on their second visit; the mean difference was 0.01 logMAR and 95% of differences were between -0.12 and 0.12. This mean difference is significantly bigger than 0 (one sample t test, $p = 0.018$, $t = -2.38$, $df = 210$). The interobserver (tester) variability was estimated from the results from 165 children who were re-examined by a different orthoptist from the one they originally saw. The median (IQR) difference between pairs of different testers was 0.02 (-0.02 to 0.06) and 95% of differences were between -0.12 and 0.14 logMAR units. The corresponding mean ICC for all pairs of orthoptists was 0.76 (0.69 to 0.82), $F = 4.3$, $df = 164$. The intraobserver (test-retest) variability was estimated from the results of children who were re-examined by the same orthoptist; the median (IQR) difference between visits was -0.01 (-0.02 to 0.05) logMAR and 95% of differences were between -0.14 and 0.12 logMAR units. The corresponding mean ICC for all orthoptists was 0.86 (0.74 to 0.92), $F = 7.0$, $df = 45$.

In the separate clinic to which children with strabismus or acuity of 0.2 or less were invited, the differences between testing with pinhole and testing with a full correction (or none for emmetropes) were assessed. Results obtained using the pinhole tended to be slightly worse than those obtained using full correction: the median (IQR) difference was 0.04 (-0.02 to 0.12) logMAR and 95% of differences fell between -0.16 and 0.30 logMAR units. The corresponding ICC was 0.83 (0.75 to 0.88), $F = 6.6$, $df = 294$. Almost identical results were obtained when excluding the emmetropes and examining the data from only the 141 children who wore glasses that were found not to need changing by the optometrist.

RESULTS

Overall, 8042 children attended, 1917 of whom were involved in the RCT and have been reported separately.¹² Of the remaining 6125, another 44 had known developmental delay, organic eye disease, or developmental syndromes and were excluded from this analysis, leaving 6081 children whose results are reported here. Of these, 1516 (24.9%) had been offered orthoptic preschool vision screening and 1019 (16.7%) had actually received it.

Differences between the two groups (children who received preschool screening v children who did not)

Factors other than exposure to preschool vision screening that were significantly associated with the worse eye acuity are shown in Table 1, together with their distribution in each of the two groups (received v did not receive screening). The children who received the preschool screening had on average older, better educated mothers who were less likely to have smoked during pregnancy than were children who did not receive it (that is, those who were invited but did not attend plus those not invited); maternal age at birth: $p = 0.013$; maternal smoking in the first trimester: $p = 0.011$ or second trimester: $p = 0.018$; highest level of education achieved by the mother: $p < 0.0001$. There were no statistically significant differences in any other variables between the two groups.

The prevalence of amblyopia at 7½ years in children

Amblyopia at 7½ years was less common among children who had received orthoptic preschool screening, for all definitions of amblyopia. The raw data and odds ratios are shown in Table 2. Also shown are the results of adjustment for the potentially confounding variables shown in Table 1. Adjustment increased the confidence intervals for the ORs such that the reductions in amblyopia A and amblyopia C in the preschool screening group were no longer statistically borderline or significant respectively.

Table 1 Factors associated with the main study outcome (mean acuity in worse seeing eye) and their distributions in the two groups (children who received screening compared with those who did not) (n = 6081)

	No	Worse eye acuity (logMAR units) mean = -0.009 (SD = 0.098) (n = 5474)	Distribution in children who received PSVS (n = 1019) (%)	Distribution in children who did not receive PSVS (n = 5062) (%)
1st degree relative has history of squint or lazy eye				
No	4578	-0.012 (0.091)	862 (84.6%)	4231 (83.6%)
Yes	895	0.007 (0.128)	157 (15.4%)	831 (16.4%)
F (p)		30.40 (<0.0001)		
Sex				
Male	2557	-0.012 (0.093)	531 (52.1%)	2384 (50.2%)
Female	2593	-0.005 (0.099)	488 (47.9%)	2364 (49.8%)
F (p)		7.90 (0.005)		
Housing tenure				
Owned/mortgaged	4083	-0.011 (0.096)	778 (83.8%)	3708 (82.1%)
Council	458	0.005 (0.105)	76 (8.2%)	456 (10.1%)
Rented	373	-0.012 (0.090)	74 (8.0%)	354 (7.8%)
F (p)		5.27 (0.005)		
Mum's highest educational level				
Vocational/CSE	1049	0.003 (0.108)	167 (17.9%)	1013 (22.6%)
GCSE/O level	1752	-0.009 (0.091)	300 (32.2%)	1642 (36.7%)
A level or higher	2078	-0.017 (0.095)	464 (49.9%)	1823 (40.7%)
F (p)		15.27 (<0.0001)		
Maternal age (years)				
< 25	812	-0.006 (0.087)	149 (15.4%)	777 (16.4%)
25-29	2060	-0.004 (0.101)	354 (36.6%)	1933 (40.7%)
30+	2278	-0.014 (0.096)	465 (48.0%)	2038 (42.0%)
F (p)		6.36 (0.002)		
Smoked 1st trimester				
None	4024	-0.011 (0.092)	776 (90.1%)	3675 (80.3%)
1-9	468	-0.008 (0.102)	18 (2.1%)	427 (9.3%)
10+	477	0.007 (0.127)	67 (7.8%)	476 (10.4%)
F (p)		8.12 (<0.0001)		
Smoked 2nd trimester				
None	4239	-0.011 (0.093)	809 (86.7%)	3877 (84.8%)
1-9	362	-0.004 (0.108)	73 (7.8%)	325 (7.1%)
10+	368	0.103 (0.124)	51 (5.5%)	372 (8.1%)
F (p)		9.11 (<0.0001)		
Birth weight				
< 2500 g	282	0.026 (0.131)	50 (5.2%)	263 (5.6%)
2500-3999 g	4174	-0.010 (0.090)	811 (83.9%)	3825 (81.1%)
4000 g	665	-0.013 (0.117)	106 (11.0%)	629 (13.3%)
F (p)		19.44 (<0.0001)		
Gestation				
< 37 weeks	317	0.012 (0.112)	57 (5.9%)	291 (6.1%)
37+ weeks	4833	-0.010 (0.095)	911 (94.1%)	4457 (93.9%)
F (p)		15.44 (<0.0001)		
Admission to SCBU				
Yes	336	0.005 (0.102)	61 (6.6%)	306 (6.9%)
No	4507	-0.011 (0.094)	864 (93.4%)	4132 (93.1%)
F (p)		9.34 (0.002)		
Duration of breastfeeding				
Never	876	0.003 (0.106)	152 (17.2%)	817 (19.7%)
< 3 months	706	-0.007 (0.087)	135 (15.3%)	564 (13.6%)
3+ months	3050	-0.016 (0.093)	598 (67.5%)	2766 (66.7%)
F (p)		15.32 (<0.0001)		

Also tested and not significantly associated with the outcome were: Use of car (yes/no), Alcohol consumption 1st trimester (none/<1 glass/week), 1+ glass/week), Alcohol consumption 2nd trimester (none/<1 glass/week), 1+ glass/week), Hard drug use during pregnancy (yes/no). The number for each cell differs from the totals shown in the header columns when there are incomplete data for some children for that variable.

Similar proportions of children in each group with amblyopia A had a strabismus at their final assessment (including microstrabismus of less than 10 pd); 4/11 (36%) in the group who received screening v 38/100 (38%) in the group who received no screening: $p = 0.82$, $\chi^2 = 0.05$, $df = 1$.

Numbers of children treated with patching before 7½ years, in each group

Statistically similar proportions of children in each group had been treated with patching in the past; 166/5062 or 3.3% (2.8 to 3.8) of those who were not screened preschool, compared with 25/1019 or 2.5% (1.6 to 3.6) of those who were; $p = 0.17$.

There were children in each group who were amblyopic at the final assessment but who had not previously been treated with patching: four of the 11 amblyopic children who did receive preschool screening (36%) had not had patching compared with 47 of the 100 amblyopic children who did not

receive preschool screening (47%) and also had not had patching: $p = 0.72$, $\chi^2 = 0.12$, $df = 1$. Of these untreated children, none in the preschool screened group was strabismic, whereas in the preschool unscreened group, four were esotropic and one had a hypertropia.

Results of patching treatment for children in each group

The mean (SD) logMAR acuities after patching treatment in the worse seeing eyes were better for children who had received preschool screening than for those who had not: 0.14 (0.18) v 0.20 (0.23), whereas the acuities in the worse seeing eyes for children who had no previous patching treatment were very similar: -0.01 (0.09) v -0.02 (0.08) in the two groups respectively (two factor ANOVA; $p = 0.002$ for preschool screening/not and $p = 0.015$ for an interaction between patched/not and preschool screening/not, which

Table 2 Prevalence of amblyopia (using three different definitions) at 7½ years in children who did or did not receive preschool vision screening (n = 6081)

Definition of amblyopia	Prevalence in children who had preschool screening (n=1019) No (%)	Prevalence in children who did not have preschool screening (n=5062) No (%)	Unadjusted odds ratio (95% CI) p Value	Adjusted* odds ratio (95% CI) p Value
A: 0.2+ logMAR or more between best acuity of each eye	11 (1.1)	100 (2.0)	0.53 (0.27 to 1.03) p = 0.052	0.63 (0.32 to 1.23) p = 0.237
B: worse eye sees worse than 0.3 logMAR (worse than 6/12 on a Snellen chart)	7 (0.7)	65 (1.3)	0.53 (0.22 to 1.20) p = 0.108	0.72 (0.32 to 1.60) p = 0.550
C: worse eye sees 0.18 logMAR or worse (6/9 or worse on a Snellen chart)	19 (1.9)	171 (3.4)	0.54 (0.32 to 0.88) p = 0.011	0.65 (0.38 to 1.10) p = 0.161

*Adjusted for sex, highest level of maternal education, birth weight, family history of strabismus/amblyopia, and duration of breastfeeding, as these were the factors (of those in Table 1) which remained significantly associated with visual acuity in the worse seeing eye, in a multivariable analysis.

indicates that the effect of preschool screening differs depending on whether the child was treated for amblyopia or not).

Repeating this analysis for children who were or were not strabismic at 7½ revealed that for the “straight amblyopia” subgroup who had been patched in the past, receiving preschool screening was associated with a significantly better mean (SD) outcome than not receiving it: 0.06 (0.12) v 0.12 (0.17) respectively ($p = 0.009$). For the children who were strabismic at 7½ and had been previously patched, there was no such association with preschool screening: 0.27 (0.20) v 0.29 (0.24) for the screened v unscreened children respectively ($p = 0.21$). For the “straight amblyopia” subgroup, these mean values correspond to 92.9% v 86.3% (Fisher’s exact test: $p = 0.44$) of children attaining driving vision (6/12 or better) in their treated eyes in the preschool screened v not preschool screened groups respectively. For the strabismic amblyopes the corresponding figures are 62.5% v 58.9% (Fisher’s exact test $p = 0.58$) for the preschool screened v not preschool screened.

Adjustment for potentially confounding variables

All the variables in Table 1 were used in a forward stepwise multivariate regression analysis, together with “received preschool screening (yes/no)” as the exposure of interest. The results were almost identical to the original analysis, even after adjustment for family history, sex, mother’s highest educational achievement, birth weight, and duration of breastfeeding: 0.15 (95% CI 0.11 to 0.18) in the preschool screening group compared with 0.22 (95% CI 0.20 to 0.23) in the no preschool screening group ($p < 0.0001$).

Analysis according to “offered screening or not”

The coverage of the preschool programme was 67.2% (1019 children attending, out of 1516 who were invited). Amblyopia was still less common in the children offered preschool orthoptic screening, but not statistically significantly so. The prevalences of amblyopia definitions A, B, and C in the two groups (not offered v offered) were 2.0% v 1.4% ($p = 0.14$), 1.3% v 1.2% ($p = 0.59$), and 3.4% v 2.4% ($p = 0.08$), respectively.

There was no difference between the groups (offered preschool screening v not offered) in the mean acuities achieved after patching treatment. The mean acuity in the worse seeing eye was 0.20 (0.23) for children not offered preschool screening v 0.18 (0.22) for children who were offered preschool screening ($p = 0.217$). For the “straight amblyopia” subgroup, there were similar results; 0.10 (0.13) in the “offered preschool screening” group v 0.12 (0.19) in the “not offered screening” group ($p = 0.11$).

After adjustment for family history, sex, mother’s highest educational achievement, birth weight and duration of breastfeeding, the overall estimated mean results were very similar.

DISCUSSION

These data support the hypothesis that preschool screening for amblyopia leads to better acuity after treatment for affected children. The magnitude and statistical significance of this effect on vision in the worse seeing eye persisted despite adjustment for a number of potentially confounding variables, suggesting it was not because of other differences between the children. However the magnitude of this improvement is clinically small (mean difference between preschool screened v not was 3 letters on a logMAR chart). This study was only able to detect quite a large drop in prevalence (by 62%) as statistically significant, so our consistent finding of a 45% drop in the screened children is of either borderline or no statistical significance given the numbers of children in this study, yet it does fit with the robust finding of a small improvement in visual acuity after treatment in the same children. The reduction in effectiveness seen in the intention to screen analysis illustrates that, in practice, obtaining only 67% coverage of the population at risk attenuated any benefit attributable to the screening to levels undetectable in a study of this size. The only other prospective UK based study comparing orthoptic preschool screening v none, found a similar lack of effect on the prevalence of amblyopia (definition C) using an intention to screen approach; however, they did not consider children who did or did not attend separately.¹⁹ The coverage of the population achieved in this area was moderately good compared to other UK programmes²; however, the serious effects of incomplete or poor compliance with screening or treatment on the effectiveness of preschool screening have already been highlighted in another UK study.²⁰

The nested RCT carried out alongside the present study, however, found that offering intensive vision screening before 37 months was associated with clinically more important improvements in outcome (a reduction in the prevalence of amblyopia B by two thirds, and an average of one line better vision for the amblyopic eyes in children who had been treated) compared with screening at 37 months.¹² Taken together, our two studies (the nested RCT and this “natural experiment”) support the hypotheses, firstly, that treatment for amblyopia does improve visual acuity and, secondly, that on average, the results of treatment after screening are better for screening before 37 months than after 37 months,¹² and slightly better again after screening at 37 months than at school entry, especially for children with straight eyed amblyopia. This may be the result of age related changes in the plasticity of the visual system, or in compliance or in other undescribed factors.

These observations must be considered with other matters such as the likelihood of screening the whole target population, the cost effectiveness of screening and treatment, and the individual and societal benefits to be expected from reducing the burden of amblyopia. Coverage of the whole population at risk ideally requires a coordinated approach

between different aspects of the child health and surveillance network, such as developmental reviews, vaccinations, and other screening programmes, in order to be successful and to minimise resources expended and efforts required by the children's families. Few cost effectiveness data are available for preschool screening programmes, although recent data from Germany have emphasised the importance of different prevalence rates for the target condition being sought and of the effectiveness of the screening tests, to overall costs.^{21–24} The benefits to society of effective detection and treatment for amblyopia include preventing incapacitating visual impairment if an individual with unilateral amblyopia loses their better eye. A national study has recently reported that this will happen to approximately 33 amblyopic (using definition B) individuals per 100 000 total population, by the age of 95 years¹⁸ and that only 10% of these would be expected to gain useful vision in their previously amblyopic eye.¹⁷ There would therefore be considerable benefits to individuals with amblyopia and to the providers of the care and financial support they come to need, if their amblyopic eyes could be more effectively treated and so the risk of subsequent bilateral and socially significant or severe loss could be lessened.

The ALSPAC study population is largely representative of the UK population generally (as evidenced by comparing ALSPAC data with the 1991 census data), with the caveat that the cohort under-represents children from very deprived families, families of Asian extraction, and families where the mother was a teenager at the birth of her child. Our findings may therefore not be generalisable to children from these backgrounds. We used a proxy measure for "best corrected" acuity and therefore may have misclassified some children as amblyopic or not; however the quality control data suggest that on average agreement between the proxy measure and fully corrected acuity was good. The study was observational, therefore although the findings of better vision in treated children who had been screened were robust in a multivariate analysis with several potential confounders, other unaccounted for factors may also have affected the results. Overall, however, the findings from this study clearly suggest a small benefit in terms of final acuity after treatment for children who had amblyopia and were screened preschool, but on a population level this programme had little effect on the overall burden of amblyopia. This was even true for the straight eyed subgroup who appeared to derive more benefit from screening than did the strabismic amblyopes. However, this study was not designed to investigate fully the effect of screening on children with subtypes of amblyopia and we do not have full data for all children regarding when they first received different types of treatment (that is, patching rather than glasses). There may therefore be further differential effects of age at screening or treatment for the different subtypes of amblyopia, investigation of which would require dedicated studies.

At the final assessment, the majority of children with amblyopia at 7½ were straight eyed, as were nearly all the amblyopes who had not had patching treatment previously. All the untreated children had been offered screening at school entry and therefore these children represent false negatives of school based screening, unless they developed their amblyopia after age 4–5 years. This seems unlikely as evidence suggests 6 years of age may be the upper age limit for developing amblyopia, which becomes increasingly less likely as a child's age increases from infancy up to 6 years.²⁵

There may be important improvements in outcome if children can be effectively screened earlier than was done here. Modelled data from our RCT,¹⁵ and from other studies, suggest that some forms of refractive screening may be more effective than acuity testing^{26–28} at detecting young children at risk of having amblyopia. The likely effectiveness of such techniques depends heavily on the accuracy of the device used and on the specificity (which dictates the number of false positives referred) of the programme.

The results of the present study do not conflict with the interim recommendations before the National Screening Committee, which are that the "best buy" at present, pending further evidence, is orthoptic screening for amblyopia at school entry.^{29–30} Coverage at this age is likely to be high and acuity testing by orthoptists is likely to be more accurate than by other professionals.^{31–32}

However, the data in both the present study and our companion paper suggest that on average, better results are obtained after earlier treatment for amblyopia. More research is needed, therefore, to explore whether photorefractive or other technologies could be sufficiently accurate to be useful in a pragmatic programme screening for amblyopia children aged 2–3 years (that is, once amblyogenic refractive error is likely to be more readily distinguishable from resolving, infantile refractive error¹⁵), who would then be expected to benefit from age associated improvements in treatment.

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CONTRIBUTORS

CW designed and managed the study with support from JMS, RAH, and IH; JG designed and manages the ALSPAC study; CW and KN analysed the data and all authors contributed to the manuscript; CW acts as guarantor.

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REFERENCES

- Wiesel TN. Postnatal development of the visual cortex and the influence of the environment. *Nature* 1982;**299**:582–91.
- Snowdon S, Stewart-Brown S. *Preschool vision screening: results of a systematic review*. York: NHS Centre for Reviews and Dissemination, University of York, 1997 April 1997. CRD Report 9.
- Harrad RA, McKee SP. Preschool vision screening: results of a systematic review. *Surv Ophthalmol* 1999;**43**:374–6.
- Rahi JS, Dezateux C. Editorial: The future of preschool vision screening services in Britain. *BMJ* 1997;**315**:1247–8.
- Fielder A. Review article did not separate review and implementation processes [letter]. *BMJ* 1998;**316**:938.
- Rahi J, Williams C, Bedford H, et al. Screening and surveillance for ophthalmic disorders and visual deficits in children in the United Kingdom. *Br J Ophthalmol* 2001;**85**:257–9.
- De Vries J. Anisometropia in children: analysis of a hospital population. *Br J Ophthalmol* 1985;**69**:504–7.
- Epelbaum M, Milleret C, Buisseret P, et al. The sensitive period for strabismic amblyopia in humans. *Ophthalmology* 1993;**100**:323–7.
- Flynn J, Woodruff G, Thompson J, et al. The therapy of amblyopia: an analysis comparing the results of amblyopia therapy utilizing two pooled data sets. *Trans Am Ophthalmol Soc* 1999;**97**:373–90.
- Kutschke PJ, Scott WE, Keech RV. Anisometropic amblyopia. *Ophthalmology* 1991;**98**:258–63.
- Hiscox F, Strong N, Thompson JR, et al. Occlusion for amblyopia: a comprehensive survey of outcome. *Eye* 1992;**6**:300–4.
- Williams C, Northstone K, Harrad R, et al. ALSPAC Study Team. Amblyopia treatment outcomes after screening before 3 years vs. at 3 years of age—follow-up from a randomised trial. *BMJ* 2002;**324**:1549–51.
- <http://www.alspac.bris.ac.uk/Default.shtm>

- 14 **Golding J**, Pembrey M, Jones R, *et al.* ALSPAC—the Avon Longitudinal Study of Parents and Children. I. Study methodology. *Paediatr Perinat Epidemiol* 2001;**15**:74–87.
- 15 **Williams C**, Harrad RA, Harvey I, *et al.* Screening for amblyopia in preschool children: results of a population-based, randomized controlled trial. *Ophthalmic Epidemiol* 2001;**8**:279–95.
- 16 **Attebo K**, Mitchell P, Cumming R, *et al.* Prevalence and causes of amblyopia in an adult population. *Ophthalmology* 1998;**105**:154–9.
- 17 **Rahi JS**, Logan S, Borja MC, *et al.* Prediction of improved vision in the amblyopic eye after visual loss in the non-amblyopic eye. *Lancet* 2002;**360**:621–2.
- 18 **Rahi J**, Logan S, Timms C, *et al.* Risk, causes, and outcomes of visual impairment after loss of vision in the non-amblyopic eye: a population-based study. *Lancet* 2002;**360**:597–602.
- 19 **Bray L**, Clarke M, Jarvis S, *et al.* Preschool vision screening: a prospective comparative evaluation. *Eye* 1996;**10**:714–18.
- 20 **Williamson T**, Andrews R, Dutton G, *et al.* Assessment of an inner city visual screening programme for preschool children. *Br J Ophthalmol* 1995;**79**:1068–73.
- 21 **Schlichtherle S**, Gandjour A, Neugebauer A, *et al.* The cost-effectiveness of screening strategies for amblyopia: a preliminary report. *Strabismus* 2000;**8**:291–5.
- 22 **Konig HH**, Barry JC. Economic evaluation of different methods of screening for amblyopia in kindergarten. *Pediatrics* 2002;**109**:e59.
- 23 **Konig HH**, Barry JC, Leidl R, *et al.* Cost-effectiveness of orthoptic screening in kindergarten: a decision-analytic model. *Strabismus* 2000;**8**:79–90.
- 24 **Konig HH**, Barry JC, Leidl R, *et al.* Economic evaluation of orthoptic screening: results of a field study in 121 german kindergartens. *Invest Ophthalmol Vis Sci* 2002;**43**:3209–15.
- 25 **Keech RV**, Kutschke PJ. Upper age limit for the development of amblyopia. *J Pediatr Ophthalmol Strabismus* 1995;**32**:89–93.
- 26 **Hirai H**, Nishino J, Saishin M, *et al.* Necessity for and problems with refractometry for mass vision screening in school children. *Folia Ophthalmol Jap* 1995;**46**:1172–5.
- 27 **Miller JM**, Harvey EM, Dobson V. Visual acuity screening versus noncycloplegic autorefraction screening for astigmatism in Native American preschool children. *J Aapos* 1999;**3**:160–5.
- 28 **Miller JM**, Dobson V, Harvey EM, *et al.* Comparison of preschool vision screening methods in a population with a high prevalence of astigmatism. *Invest Ophthalmol Vis Sci* 2001;**42**:917–24.
- 29 **Hall DB**, Elliman D. *Health for all children*. 4th ed. Oxford: OUP, 2003.
- 30 <http://www.doh.gov.uk/nsc/index.htm>
- 31 **Wormald RPL**. Preschool vision screening in Cornwall: performance indicators of community orthoptists. *Arch Dis Child* 1991;**66**:917–20.
- 32 **Bolger PG**, Stewart-Brown SL, Newcombe E, *et al.* Vision screening in preschool children: comparison of orthoptists and clinical medical officers as primary screeners. *BMJ* 1991;**303**:1291–4.

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