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A comparison of visual outcomes at age 8 years in children detected by pre-school screening with those detected at reception screening

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Abstract

Aim: **To compare the effectiveness of screening for visual defects in a cohort of pre-school children (3–3½ years) versus screening in primary school children (4–5¼ years). Specifically we compared the numbers attending in each group and the visual outcomes at age 8 years.**

Methods: **The design was an observational prospective cohort study comparing children screened and treated in two age groups on visual outcome in the worse seeing eye at 8 years of age. The cohorts were matched for socio-economic status by area of residence. A positive outcome was defined as an improvement in vision of 0.3 logMAR or more in the worse seeing eye from the baseline visual acuity to final follow-up.**

Results: **In the pre-school group, 414 (52.3%) children were screened out of 792 invitees. In the school group, 785 (94.9%) children were screened out of 827 invitees. Sensitivity and specificity of the screening were similar for the two groups, but the increased uptake at school enabled many more children to be screened. After treatment, a positive outcome in the worse seeing eye was achieved in 18 of 42 children (43%) of the pre-school group and in 41 of 84 children (49%) of the school group.**

Conclusion: **Our study suggests that it may be better to screen children at school because it is much easier to achieve coverage of the population. Visual outcome at age 8 years appears to be similar in children screened at pre-school age and those screened at school.**

Key words: Pre-school, School, Visual defects, Visual outcome, Visual screening

Introduction

Amblyopia is a form of cerebral visual impairment caused by abnormal visual input, commonly uncorrected refractive error and/or squint, during the sensitive period of development.[1–4] It has been proposed that treatment is effective only during this sensitive period, which varies for different types of amblyopia but most commonly lasts until 7 years of age.[5–7] Experimental data from animals seem to show decreasing responsiveness to treatment for visual disorders with increasing age.[8] However, Epelbaum *et al*. found that, in children, although maximum improvement in strabismic amblyopia occurred if occlusion was started before age 3 years, improvement was possible up to 12 years of age.[9] Existing data from retrospective studies have produced conflicting results regarding the importance of early detection and treatment in outcome.[10–13]

Pre-school screening leading to early diagnosis and treatment instigation may improve the treatment outcome;[14] however, later treatment for amblyopia may still provide a favourable outcome.[9] Sensitivity and specificity may be reduced in the pre-school group due to their immaturity and the less sensitive vision tests necessary in this age group, whereas school-age children will be more familiar with the alphabet and their cooperation may be better.[15] There may also be more efficient use of professional time in the latter group as it may be more cost-effective to screen in school where more children may be screened per hour. Attendance for treatment may be preferable for both parent and child before formal education commences.[9] However, at the screening stage, attendance and uptake may be better in the school group: the child is already present in school so less parental effort is required for he or she to attend screening.

Nationally there has been debate regarding the validity of screening for visual defects and strabismus, and the report *Preschool Vision Screening: Results of a Systematic Review*[16] called for 'trials to be undertaken in children both of 3 to 4 years of age and 5 to 6 years to determine whether screening at age 3 to 4 confers any benefit over screening at school entry'. The fourth Hall Report[15] states that research is 'important to determine the extent to which delay in diagnosis and treatment of amblyopia between the ages of 3 and 5 years affects the outcome'.

This study had two aims: (1) to compare the numbers of children attending for screening in the two cohorts; (2) to compare the visual outcomes at age 8 years.

Methods

Design

This was an observational prospective cohort study

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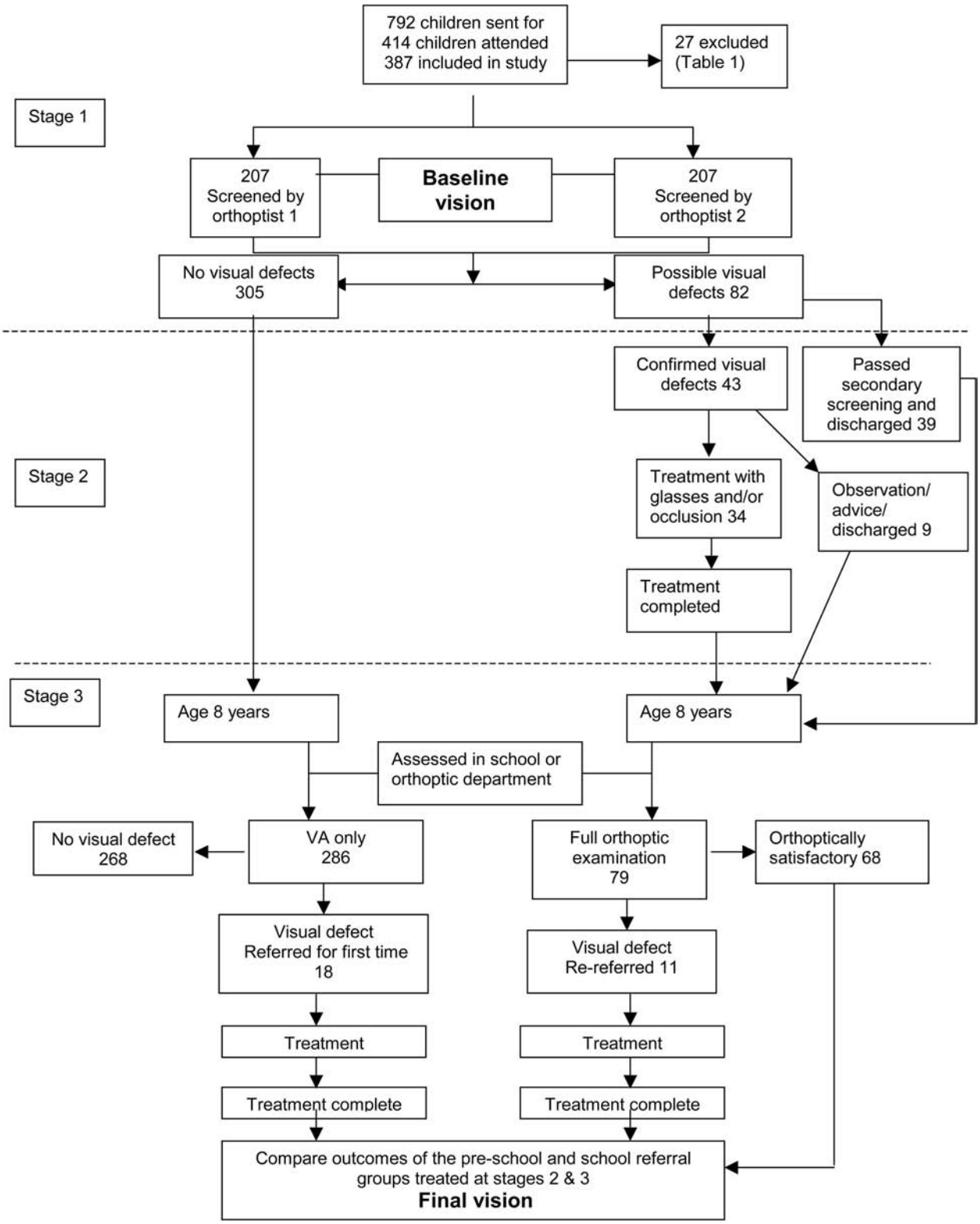

Fig. 1. Flow chart for the pre-school group.

comparing children screened and treated in two age groups on visual outcome in the worse seeing eye at 8 years of age. Orthoptic screening, assessment and treatment, together with final assessment, were performed by the same two orthoptists throughout. Children who failed to pass the screening criterion were referred to the orthoptic clinic for further assessment (secondary screening) with one of the two orthoptists involved in the study. The study took place in three stages (Figs. 1 and 2).

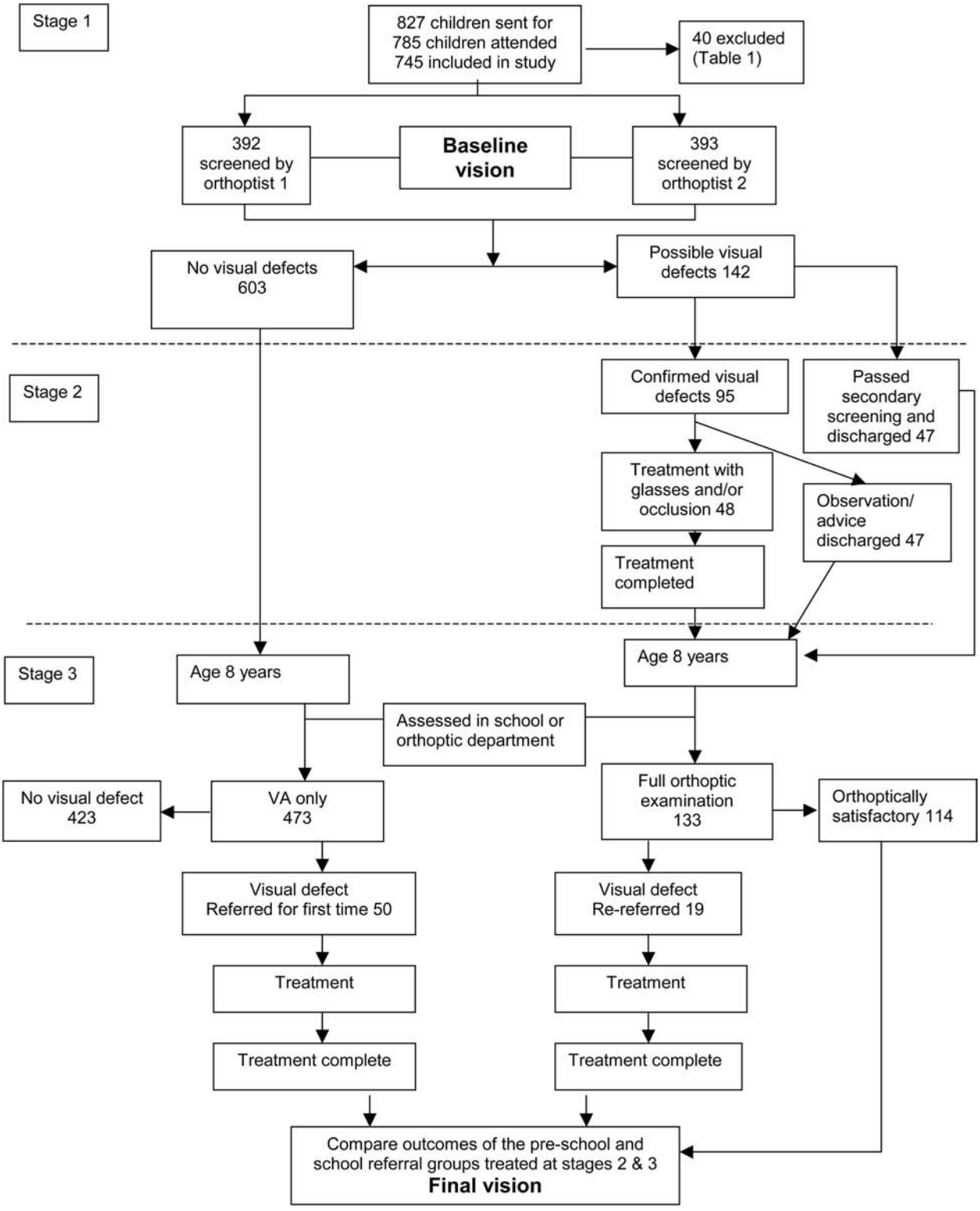

Fig. 2. Flow chart for the school group.

Sample size

Sample size was based on the numbers required at the stage 2 treatment phase (Figs. 1 and 2). Power calculations (based on 80% power using a one-tailed Fisher's exact test) indicated that 65 children with defects needed to be treated from each group to detect a clinically significant difference in screening outcome. Therefore, taking into account the estimated event rate (taken to be 8%[1,16]), 700 children needed to be screened in each group.

After those who had passed secondary screening had been discharged to the 'no visual defects group', there

Table 1. Exclusions from stage 1 screening

	Male	Female
Pre-school group		
Previously diagnosed eye condition	12	8
Learning difficulties that precluded the specified tests	5	2
Previous visual screening	0	0
Total male + female = 27/414 (3.4%)	*17*	*10*
School group		
Previously diagnosed eye condition	20	17
Learning difficulties that precluded the specified tests	3	0
Previous visual screening	0	0
Total male + female = 40/785 (4.8%)	*23*	*17*

were only 43 children remaining in the pre-school treatment group compared with 95 children in the school treatment group. Therefore, we carried out a post-hoc power calculation to verify that we had adequate power to detect the effect of interest, i.e. a difference in the proportion of children in each group with an improvement of 0.3 logMAR or more in the worse seeing eye. These calculations showed that a Fisher's exact test with a 0.05 one-sided significance level had 81% power to detect a difference between the pre-school and school groups.

Subjects

We recruited two cohorts of children: (1) a pre-school group of children aged 3–3½ years born between 1 September 1996 and 31 December 1997; (2) a group of children in their first year of primary school aged 4–5¼ years born between 1 September 1994 and 31 August 1995. Written invitations were sent directly to parents of the pre-school group following agreement by their general practitioner. Invitations for the school group were sent via their head teacher. Written, informed consent was obtained from the parents of all participating children.

Exclusions

We excluded children who had had previous visual screening, a pre-diagnosed eye condition or learning disabilities that precluded the study's specified tests (Table 1).

Setting

The study took place in 13 general practitioner surgeries (pre-school group) and in 23 primary schools in Preston, Lancashire (school group).

Tests used for screening

Tests were selected for their portability and ease of use. Wherever possible the Bailey Lovie logMAR chart was used. Where this proved inaccurate due to insufficient cooperation, a Snellen chart, Clement Clarke Cambridge Crowding Cards (using the 'crowded card' test), and in a few cases a Sheridan Gardiner Single Letter Test, commensurate with age or ability, was used. The results were converted using a logMAR conversion table to enable comparison of final visual acuities.

Table 2. Children referred for further assessment (secondary screening) from the stage 1 screening phase

Secondary screening	Pre-school group	School group
Orthoptically satisfactory at second test *Discharged*	39/387 (10%)	47/745 (6.3%)
Reduced vision both eyes *Referred for observation/ treatment*	21/387 (5.5%)	38/745 (5.1%)
Reduced vision one eye *Referred for observation/ treatment*	15/387 (3.9%)	37/745 (5%)
Strabismus *Referred for observation/ treatment*	5/387 (1.3%)	8/745 (1.1%)
Other *Referred for observation/ treatment*	2/387 (0.5%)	12/745 (1.6%)
Totals referred	82/387 (21.2%)	142/745 (19.1%)
Confirmed visual defects	43/387 (11.1%)	95/745 (12.75%)

The Cover Test was performed at 33 cm and 6 m distances to determine the presence of a latent or manifest strabismus. Ocular movements were examined in the nine positions of gaze to determine the presence of abnormalities of ocular motility. To test for binocularity, convergence was examined using an accommodative target; a 20^{Δ} dioptre base-out prism was placed in front of either eye to examine fusional reserves; and stereoscopic acuity at 40 cm was examined using the Frisby stereo-test.

Screening phase (stage 1)

In the pre-school group, orthoptic vision screening was carried out between January 2000 and January 2001. In the school group it was undertaken between September 1999 and February 2000.

Referral criterion at stage 1

Children with vision poorer than 0.0 logMAR in one or both eyes were referred for further assessment. As this was a research project the 0.0 logMAR level was chosen, rather than 0.2 logMAR as recommended for screening by Hall,[15] to minimise the possible false-negative referral rate.

Children referred who passed screening at the second attempt, i.e. secondary screening, were discharged (Table 2). These children were given a full orthoptic examination at age 8 years. However, for the purpose of analysis, as they were orthoptically satisfactory they were included in the group with no visual defects.

Treatment phase (stage 2)

Children with confirmed visual defects were followed up in the orthoptic clinic for observation and/or treatment (Table 3) and referred for refraction and examination by the optometrist and/or ophthalmologist.

Discharge/final vision testing took place at age 7½–8½ years, when the visual system is considered mature.[7,17]

Follow-up phase (stage 3)

All children involved in the study, rather than just those treated at stage 2, were re-examined at age 7½–8½ years,

Table 3. Observation and treatment of the stage 2 treatment group

	Pre-school group (43 children)	School group (95 children)	Total
Occlusion	M 3, F 1 4/42 (10%)	M 3, F 1 4/95 (4%)	8/137 (5.8%)
Glasses	M 8, F 8 16/42 (38%)	M 20, F 10 30/95 (32%)	46/137 (33.6%)
Glasses + occlusion	M 5, F 9 14/42 (33%)	M 8, F 6 14/95 (15%)	28/137 (20.4%)
Observation	M 5, F 4 9/42 (21%)	M 21, F 26 47/95 (50%)	56/137 (40.9%)
Total no. with refractive errors	M 13, F 17 30/42 (71%)	M 28, F 16 44/95 (46%)	M 41, F 33 74/137 (54.0%)
Total no. with amblyopia	M 8, F 10 18/42 (43%)	M 11, F 7 18/95 (19%)	M 19, F 17 3/137 (26.3%)

with the exception of those lost to follow-up due to non-attendance on at least two occasions or those who had left the area. If glasses had previously been prescribed, the corrected visual acuity was measured. Children in the pre-school group were re-examined from January to September 2005 and children in the school group were re-examined from April to July 2003. Further referral and treatment was carried out when necessary and therefore the study continued until July 2006. The final vision of the stage 1 referral groups was recorded at this time between 7½ and 8½ years of age, not at discharge, unless discharge corresponded with stage 3 testing. The final vision of the stage 3 referral groups was recorded with spectacle correction between 4 and 6 weeks after refraction.

At stage 3 we included only those children who had previously been seen at stage 1 of the study and therefore had a baseline vision test for comparison, rather than screening all children initially invited for screening but who failed to attend or declined their appointment.

The results of the pre-school and school stage 1 referral groups were compared for treatment outcomes at the end of stage 3.

Referral criterion at stage 3

Children with vision poorer than 0.1 logMAR in either eye were referred to the hospital optometrist. Children with 0.1 logMAR or better passed screening at this stage and were not referred.

Data analysis

Attendance was calculated as the number of children who attended pre-school screening following two separate offers of an appointment and the number of pupils screened in school on two separate days with parental consent. Sensitivity and specificity, including the false-positive and false-negative referral rates, were analysed (Table 4).

Treatment outcomes were compared by subtracting the final vision at age 8 years (stage 3) in the worse seeing eye from the initial vision in the same eye at the first visit in the stage 2 treatment phase, i.e. before treatment began (Tables 3 and 5). An improvement of at least 0.3 on the logMAR scale in the worse seeing eye by the age of 8 years was considered a positive outcome of treatment in the comparison of the two cohorts. For interest, refractive errors at age 8 years were compared and categorised into minimal, significant[18] and high (as shown in Tables 6 and 7).

Table 6. Refractive errors of the stage 2 treatment group

Refractive error	Pre-school group	School group
High	6/42 (14%)	5/95 (5%)
Significant	20/42 (48%)	24/95 (25%)
Minimal (wearing glasses)	5/42 (12%)	9/95 (10%)
Minimal (no glasses advised)	3/42 (7%)	34/95 (36%)
No refractive error	8/42 (19%)	23/95 (24%)

Results

Attendance

In the pre-school group, 387 attended out of 792 invitees (48.9%) (Table 8 and Fig. 1). In the school group, 745 eligible children attended out of 827 invitees (90.1%) (Table 8 and Fig. 2). The number of referrals was significantly smaller for the pre-school group, owing to a 52.3% attendance rate for this group (414/792 attended) compared with a 94.9% attendance rate for the school group (785/827 attended). However, the proportions referred out of those examined were the same: 86/387 (22%) from the pre-school group and 162/745 (22%) from the school group.

Sensitivity and specificity

The sensitivity and specificity of screening in those tested from the two groups were similar (Table 4). However, the authors acknowledge that the data presented represent only the groups tested, not the entire cohort targeted, and are therefore incomplete. This was

Table 4. The sensitivity and specificity of the stage 1 screening phase

	Sensitivity	Specificity	Positive predictive value	Negative predictive value	Yield
Pre-school group	95.6% (43/45)	88.7% (305/344)	52.4% (43/82)	99.3% (305/307)	11.1% (43/389)
School group	100% (95/95)	92.8% (603/650)	66.9% (95/142)	100% (603/603)	12.75% (95/745)

Table 5. Visual outcomes in the worse seeing eye

	Positive treatment outcome: improvement of 0.3 logMAR or more	Final vision 0.18–0.00 logMAR	Final vision 0.3–0.19 logMAR	Improvement to <0.3 logMAR	No improvement
Pre-school group	**18/42 (43%)**	33/43 (77%)	4/43 (9%)	4/43 (9%)	2/43 (5%)
School group	**41/84 (49%)**	82/95 (86%)	3/95 (3%)	6/95 (6%)	4/95 (4%)

Table 7. Classification of refractive errors of the stage 2 treatment group

Refractive error	Hypermetropia	Myopia	Astigmatism	Anisometropia
High (wearing glasses)	⩾ +5.00 DS	⩾–4.25 DS	⩾ 3.00 DC	⩾ 2.00 DS or DC
Significant (wearing glasses)	At least +2.00 DS in the worse seeing eye	Any myopia	At least 1.50 DC	At least 1.00 DS or DC
Minimal (wearing glasses)	Any value less than significant	Any value less than significant	Any value less than significant	Any value less than significant
Minimal (no glasses advised)	Any value less than significant	Any value less than significant	Any value less than significant	Any value less than significant
No refractive error				

Significant values are taken from the British College of Optometrists: The Directorate for Optometric Continuing Education and Training, *Vision in Childhood*, 1992, p. 9.[18]

Table 8. The difference in attendance between the two groups

Eligible children	Pre-school group (792 children)	School group (827 children)
Absent/failed to attend	286/792 (36.1%)	33/827 (4.0%)
Declined screening	92/792 (11.6%)	9/827 (1.0%)
Attended but excluded	27/792 (3.4%)	40/827 (4.8%)
Total screened and included in study	387/792 (48.9%)	745/827 (90.1%)
Total referred	86/387 (22.0%)	162/745 (22.0%)
Number referred and attended	82/387 (21.0%)	142/745 (19.0%)
	82/792 (10.4%)	142/827 (17.2%)
Failed to attend following referral	4/86 (4.7%)	20/162 (12.3%)

because, due to time constraints, the authors were unable to examine the entire cohort between the age at screening and age 8 years.

The parameters of a screening programme that predict its performance are the sensitivity, specificity, positive predictive value and yield. The false-negative referral rate for the pre-school group was 4%; no confirmed cases of false-negative referral were found in the school group. The false-positive referral rate for the pre-school group was 11%, mainly due to lack of cooperation and maturity; that for the school group was 7%.

Visual outcome

We chose a ceiling effect of 0.00 logMAR for the analysis as this would be considered a normal level of vision by most health professionals.

In the pre-school group 18 of 42 children improved by 0.3 logMAR or more in the worse seeing eye (43%). (For one of the 43 children, an improvement of 0.3 logMAR was impossible as the difference between initial vision and final vision was less than 0.3 logMAR to start with.)

In the school group 41 of 84 children improved by 0.3 logMAR or more in the worse seeing eye (49%). For 11 of the 95 children, an improvement of 0.3 logMAR was impossible as the difference between initial and final vision was less than 0.3 logMAR to start with (Table 5).

In the pre-school group 26 of 42 children (62%) were found to have a significant or high refractive error, whereas in the school group 29 of 95 (30%) were found to have a significant or high refractive error (Tables 6 and 7).[18] However, in the school group children were more likely to have been referred with a minimal refractive error, for which glasses were not advised: 34 of 95 (36%) in the school group as opposed to 3 of 42 (7%) in the pre-school group.

Discussion

Amblyopia, caused by inadequate stimulation of the visual system during the critical period, may be a result of:

1. Stimulus deprivation: In the groups studied, one child in the pre-school group was detected with this type of amblyopia, secondary to a congenital cataract.
2. Strabismic amblyopia: In the pre-school group we found 6 cases of this type of amblyopia and in the school group, 5 cases.
3. Anisometropic, meridional and ammetropic amblyopia: In the groups studied, we found 30 children with uncorrected refractive errors in the pre-school group and 44 children in the school group.

The results of our study showed there was no significant difference in the improvement in the visual acuity in the worse seeing eye between the pre-school and school groups following treatment at stage 2.

Our results are in keeping with the work of Birnbaum *et al*., who found that 'the age of 6 years is not particularly significant with regard to prognosis for amblyopia therapy' and that 'many older amblyopes can be successfully treated, and their success rates are quite similar to those obtained with younger amblyopes'.[7,9]

Although the results of our study showed there may be no disadvantage to later treatment with occlusion, there are risks to later treatment for amblyopia:

1. Intractable diplopia in patients with strabismus after the age of 6–7 years due to the risk of overcoming suppression: This was not a problem in our study. However, all patients over the age of 6 years were carefully monitored using the Sbiza bar.
2. Dissociation of a latent or intermittent deviation: Again, we found no cases of reduced control due to occlusion, though we acknowledge a potential risk.
3. Social problems due to more awareness of occlusion and bullying: This will always be a problem for this age group. We tried to be as supportive to the parents as possible, with one or two children wearing the patch full-time at home, after refusing to wear it in school.

Our data support the recommendations for screening at age 4–5 years in the fourth Hall Report.[15] The report states that 'testing before the age of 4 years appears to produce too many unreliable results' and that 'the most compelling reason for early diagnosis and treatment is that parents want it'! In our study a slightly higher

proportion of children were referred for secondary screening in the pre-school group. Secondary screening was an inevitable hazard of screening in both age groups owing to a lack of cooperation from the children but also, in the case of the pre-school group, lack of maturity. The report also importantly states that 'universal coverage may still be a problem in the pre-school years'. Due to a 50% higher attendance rate at school screening, we found it was a more cost-effective and efficient use of professional time to screen in school. The difference in attendance rates in the two groups may be because those who attended pre-school screening are more likely to be those who seek and take up healthcare, when compared with the school groups, which are not self-selected. School screening made it possible to assess more children in a shorter time, because of the large numbers of children attending the same school.

There are, however, limitations to our study, chiefly because we were not able to re-screen all the children initially sent for but who failed to attend at the screening phase. As a result, we cannot be sure of the accuracy of the sensitivity and specificity values. However, what we can say is that we did detect similar proportions of defects in each group.

Our referral rates were high in this study owing to the fact that we adopted stringent screening referral criteria. This enabled us to minimise the false-negative referral rate.

Our findings are contrary to some previous studies in which it was postulated that early screening produced a greater improvement.[8,14]

Conclusions

Delay in treatment until age 5 years may not adversely influence treatment outcome. At age 3 years we found children were more likely to have a significant or high refractive error compared with the school group, though we found no significant difference in final visual outcomes in our study between the two groups.

Increased uptake at school enabled almost 100% more children to be tested (Table 8). Screening in school therefore appears to be more cost-effective and a better use of professional time, due to improved attendance.

Ethics approval was obtained from Preston, Chorley and South Ribble Local Research Ethics Committee, The Lancashire Centre for Medical Studies, Royal Preston Hospital.

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The authors declare they have no competing interests.

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