

ORIGINAL ARTICLE

# School-entry Vision Screening in the United Kingdom: Practical Aspects and Outcomes

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## ABSTRACT

**Purpose:** To describe and assess an orthoptist-led vision screening service for school-entry (reception class) children, and report outcomes from one healthcare trust in the UK.

**Methods:** A total of 3721 children (aged 4–5 years) in reception class primary school (155 state, 3 private) underwent orthoptist-conducted vision screening. Children who failed to meet the screening criteria were referred to hospital-based eye services for re-testing and final diagnosis.

**Results:** The screening take-up rate was 96.41%; the remaining 3.59% refused/failed to consent to screening. The screening capture rate of participating children was 99.7%. A total of 11.14% of screened children failed to meet the screening criteria and were referred elsewhere; no abnormalities were found in 14% (false referral rate) of these children. Of the referred children, 53% had refractive errors requiring glasses and 42% had squints. The estimated percentages of common visual problems in screened children were 9.15% for refractive error and 3.81% for squint.

**Conclusion:** An orthoptist-led, time-of-school-entry vision screening service is ideal for successful childhood vision screening and is, thus, a valuable source of information regarding the prevalence of common visual problems among children.

**Keywords:** Children, orthoptist, school, screening, vision

## INTRODUCTION

The 2002 4th United Kingdom (UK)-endorsed Hall Report (Health for all children)<sup>1</sup> recommended, among other preventive care strategies for children, prompt introduction of an orthoptist-led program for screening 4–5-year-old children for visual defects. However, a nationwide review of the availability of vision screening programs for children is still lacking. Although the child health sub-group of the UK National Screening Committee (NSC) agreed with the Hall recommendations, as well as reviewed its policy against ongoing and available research findings,<sup>2,3</sup> there remains some controversy as to the efficiency of childhood vision screening programs in the UK. The NSC child health sub-group's review on vision screening<sup>4</sup> cites many uncertainties and/or lack of evidence regarding successful vision screening

programs. For example, while plans for managing/monitoring such programs, as well as implementation of uniform quality assurance standards are still evolving, the cost-effectiveness of primary screening services remains uncertain, with significant concerns regarding adequate resources to support such programs. Therefore, a strategic plan for the application of childhood vision screening programs in the UK remains unresolved, and school-entry (reception class) vision screening has yet to be included in the National Health Service (NHS) agenda of screening programs in the UK. Variations in program uniformity, including the nature of personnel conducting the tests, still exist, as these issues are determined by local healthcare providers.<sup>5</sup> Hence, standard, well-established pre-school vision testing programs are only in effect in certain regions of the UK.<sup>6</sup>

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While many studies dealing with the validity of pre-school vision screening programs<sup>7,8</sup> have been conducted, no published studies dealing with the efficiency or outcomes of orthoptist-led school-entry vision screening in the UK could be found; a Medline literature search (using “vision,” “screening,” “school,” and “entry” as keywords) showed no UK-based cross-sectional studies or models. In the present report, we describe the setup, outcome and efficiency of school-entry vision screening in a single NHS trust.

## MATERIALS AND METHODS

This observational study was conducted at the Chesterfield Royal Hospital (CRH) NHS Foundation Trust located in the North Derbyshire region of England. This Trust serves a population of 369,569 people across one health district. The ethnicities of the Derbyshire population is 96.0% white, 2.3% South Asian, and 1.7% black, mixed race, or Chinese,<sup>9</sup> with around 1/3 of the population living in the more rural areas of the region.

An orthoptist-led school-entry vision screening service has been in place since January 2008, prior to which screenings were carried out by school nurses. The local regional primary care trust agreed to fund the screening service, with cost analysis based on staffing, transportation, equipment and administrative expenses. A protocol was developed in line with “Health for all children”<sup>1</sup> for administering the screening service, and was approved locally by the Hospital Trust Clinical Governance Review Board. Clinical standards and audit reports of screening outcomes are provided to the trust’s governance department yearly. Orthoptist-led vision screening was offered to all reception class age (4–5 years) children who were registered with a general practitioner (GP) in North Derbyshire. If a vision problem was detected after a single assessment and re-testing was not an option, the child was referred to a hospital.

The orthoptist-led screening examination included a monocular visual acuity (VA) test (Sonksen linear crowded and single logarithm of the minimum angle of resolution, logMAR; developed by the Institute of Child Health, University College London), cover test, ocular movement test, binocularity assessment with a 20-diopter (D) prism, and Frisby stereo test. Criteria for referrals are listed in Table 1. Most children were referred to CRH or, if they lived in the west Peak District area of North Derbyshire, to Stepping Hill Hospital’s secondary screening clinic. At CRH, children were re-examined by hospital orthoptists and pediatric ophthalmologists, following which a final diagnosis and management plans were rendered. Children who failed to keep hospital eye service (HES) appointments after a post-screening referral

TABLE 1. Childhood vision screening referral criteria to hospital eye service, UK.

Uni-ocular vision $\leq 0.2$ on crowded logMAR or $\leq 0.1$ on uncrowded logMAR
Difference in vision between both eyes $\geq 0.1$ logMAR
Strabismus (esotropia, exotropia, hypertropia, or hypotropia)
Significant phoria (decompensating)
Ocular motility defect (Duane or Brown syndrome, cranial nerve palsy)
Other findings (ptosis, nystagmus)

were given another appointment, and their parents and GP informed about their non-attendance. The children’s safe-guarding team was also informed following a second attendance failure.

On average, 4000 children per school year are offered this screening service in 155 state and 3 private schools. In this report, we provide screening outcomes for the September 2009 to August 2010 school year.

Screening was carried out throughout the school year by three orthoptists. There were 14 half-day screening sessions per week, with an average of 15–18 children screened per session. Orthoptists spent, on average, 50% of their work week performing screening tests. Variations in time were built into the screening day to account for travel to more rural areas and differing abilities of the children being screened. Screening results were recorded and entered into a Microsoft Excel database by the administrative assistant, who was also responsible for sending a hard copy of results to the school health department for the child’s records, updating databases of children being screened throughout the year, providing and receiving consent forms from schools, and documenting screening results and hospital referrals.

Screening databases were populated initially from GP databases and then cross-matched with the class lists provided by the schools. Screening services were offered to all children. Consent forms, which were sent to all schools, were handed out and then collected. Additional consent forms were sent out, where required, and a reminder letter sent to parents when necessary. In cases of failed/refused consent, the GP and School Health Service were informed. Children moving into or out of a particular service area were accounted for by means of updated GP lists throughout the year. At the end of the screening year, databases were amended to include children who had missed screening at a particular school. These children, along with any children who were on our GP list but were not attending the local schools (i.e. were attending schools across the district border), were then offered a vision screening appointment at the HES during a school holiday.

The Microsoft Excel 2007 data analysis pack was used for comparing groups, with  $p$  values  $< 0.05$  considered significant, and for estimating confidence

intervals (CIs) for proportions of visual problems in this cohort.

## RESULTS

### Screening Load

A total of 4171 children were eligible for vision screening in 2009. This included 299 children who had not been screened by the end of the screening year. Figure 1 shows the total number of children to whom screening was offered, the number of those whose

parents agreed or refused to consent for screening, and the number who were successfully screened. The screening take-up rate of children in our schools was 96.41%, which is in addition to 121 children (3.29%) who were already attending the HES for various ophthalmic conditions (Table 2), thus increasing the screening capture rate to 99.7%. Figure 1 also shows the 299 unscreened children, 87 (29.1%) of whom had moved out of the region and 13 (3.7%) of whom were already enrolled in a HES elsewhere. The remaining 199 were schooled across the district border. Since these children were still registered with the study GP, they were offered a vision screening appointment at

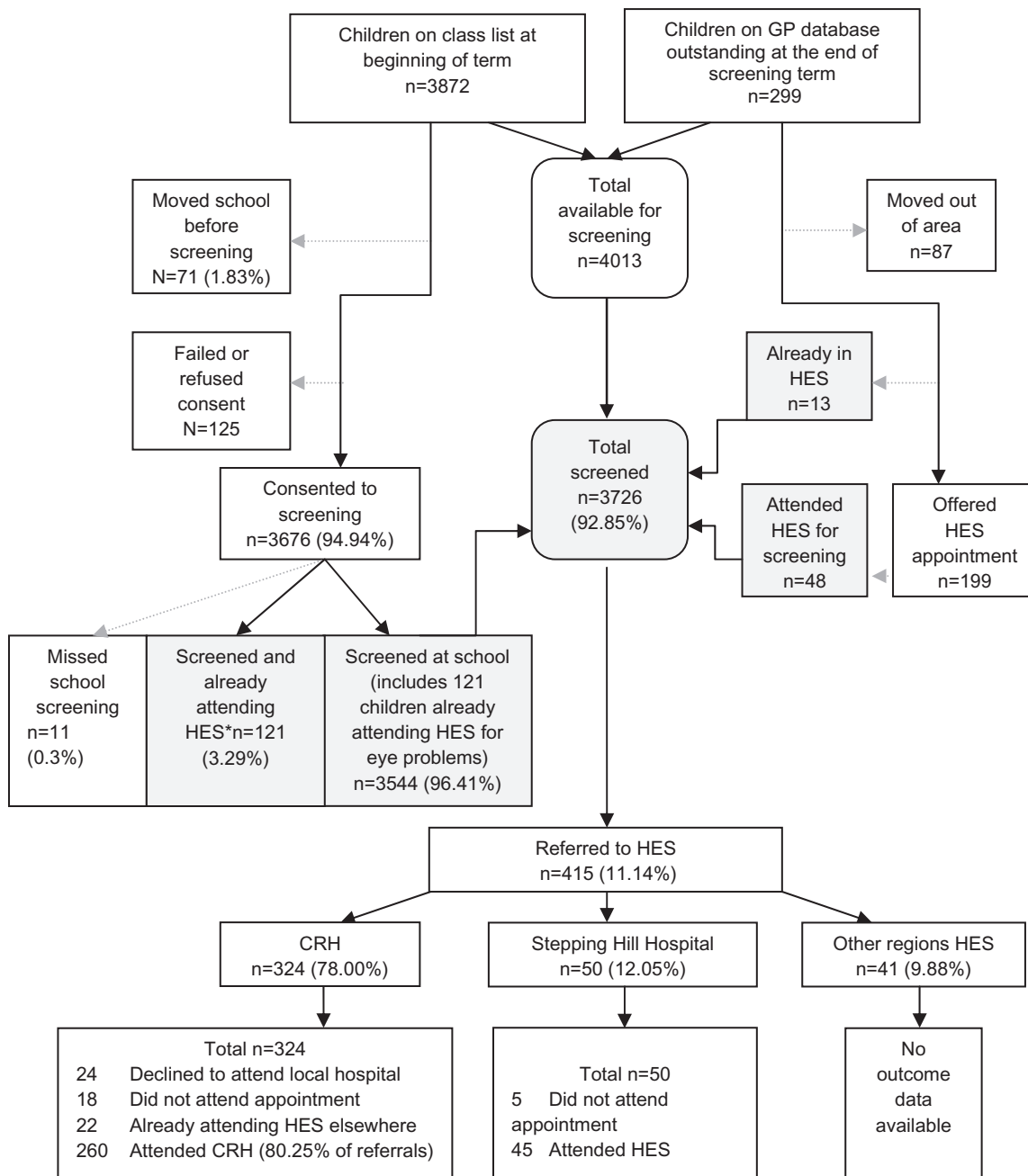


FIGURE 1. School-entry vision screening data and outcome pathways in North Derbyshire, UK; numbers in grey boxes indicate screened cases (GP, general practitioner; HES, hospital eye service; CRH, Chesterfield Royal Hospital). For details see Table 3.

TABLE 2. Diagnoses of children already attending hospital eye service, North Derbyshire, UK ( $n = 121$ ).

Condition	<i>n</i>	Condition	<i>n</i>
Refractive error glasses prescribed	34	{ Albinism Optic nerve hypoplasia Ptosis Cerebral visual impairment Sturge-Weber syndrome Congenital stationary night blindness	2
Squint	13		2
Squint and refractive error	46		1
Ocular motility	2		3
Other diagnoses	10		1
No abnormality detected	16		1

TABLE 3. Costs related to school-entry vision screening service, North Derbyshire, UK (financial year 2009–2010).

Item	Cost, £
Paid staff	
Administrative, full-time × term-time	16,800
Orthoptist	55,337
Other	
Travel	4986
Stationery, postage, vision testing books, equipment usage	2784
Overhead <sup>a</sup>	19,977
Total cost	99,884
Contract value	98,000

<sup>a</sup>Includes costs of management, support services, procurement, finance, personnel, estates, etc.

the HES. Of these 199 children, only 48 (24%) attended, while 107 (54%) failed to attend and 44 (22%) cancelled. Most cancellations were because they were attending a HES elsewhere or had already been screened in a bordering county.

### Screening Cost

The children screened in 2009 represent 92.85% of all children available for screening. In 2009, the total cost of providing school-entry vision screening by our hospital trust was £99,884 (£26.80/child screened or £24.89/child available for screening). The cost of detecting a positive case of intervention-requiring reduced vision was £280. Table 3 shows the screening cost breakdown. The chief part came from staffing the service which constituted about 2/3 of the total cost.

### Referrals to a HES

Of the 3726 children screened in 2009, 415 (11.14%) were referred to a HES. These children were referred primarily to CRH, but some were referred to bordering health services closer to their homes. Of 324 children referred to the study healthcare area, only 260 (80.25%) attended our HES. Similarly, 5 of 50 children (10%) referred to Stepping Hill Hospital also failed to appear (Figure 1). There were no

TABLE 4. Comparison of visual acuity and distance from home to hospital for children who attended versus those who did not attend HES after referral from screening, North Derbyshire, UK.

	Attendees ( <i>n</i> = 305)	Non-attendees ( <i>n</i> = 47)	<i>p</i> ( <i>t</i> ≤ <i>t</i> ) two-tail
Mean visual acuity, logMAR (SD)	0.1933 (0.1915)	0.2035 (0.188)	0.83
Mean distance from home to HES, km (SD)	11.27 (6.86)	13.07 (7.58)	0.1

HES, hospital eye service; logMAR, logarithm of the minimum angle of resolution; SD, standard deviation

significant statistical differences in VA, age, or home location between those who attended and those who failed to appear for their hospital appointments after referral (Table 4).

### Referral Reasons

Table 5 shows the reasons for referral and final diagnoses of children who attended our HES. Figure 2 is a graphic representation of VA distribution among referred children. Reduced vision in one or both eyes was the reason for referral in 74% of children. In 18% of children, an inter-ocular difference in VA >0.1 logMAR was the only reason for referral.

### Referral Outcomes and Diagnosis at the HES

As shown in Table 5, 61% of referred children had refractive error only, 18% had squint with or without refractive error, and 5% had ocular motility disorders without deviation in primary gaze; the last comprising primarily cases of upshoot in adduction with or without superior oblique palsy. Rare referrals included single cases of bilateral cataract, uveitis, corneal scarring, ptosis, and nystagmus. No abnormalities were uncovered in 14% of referrals (false referral rate) seen and re-tested in the HES, constituting 2.64% of the total screened.

Detailed data for children seen at CRH ( $n = 260$ ) indicate that 90% of children with refractive error were prescribed glasses, mainly for hypermetropia (56%) and astigmatic errors (38%), but less commonly

TABLE 5. Reasons for referral from childhood vision screening versus final diagnosis at a HES, North Derbyshire, UK (N = 260).

Referral reason	n (%)	Diagnosis at HES	n (%)
Reduced VA (both eyes)	51(20)	Refractive error glasses prescribed	138 (53)
Reduced VA (one eye)	141 (54)	Minimal refractive error, no glasses yet	17 (7)
Squint and reduced vision	25 (10)	Squint	24 (9)
Squint	19 (7)	Squint and refractive error	20 (8)
Ptosis	3 (1)	Ocular motility	14 (5)
Ocular motility	16 (6)	Ptosis	3 (1)
Other	5 (2)	Other	6 (2)
		No detected abnormality	38 (14)

HES, hospital eye service; VA, visual acuity

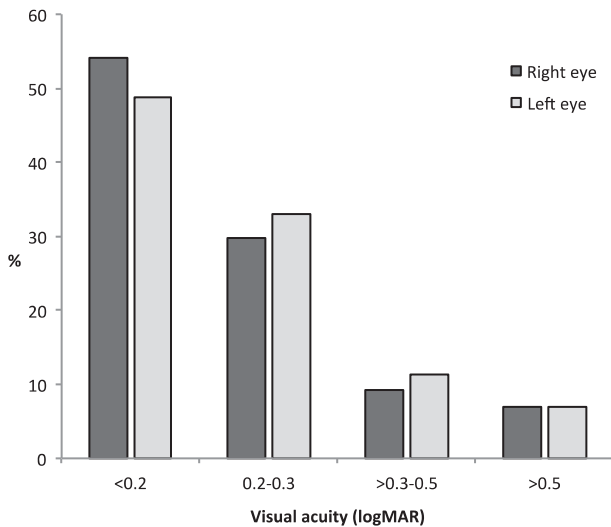


FIGURE 2. Distribution of visual acuity in children referred to a hospital eye service in North Derbyshire, UK ( $n = 252$ ) less those in whom vision testing was unsuccessful.

for myopia (6%); 46% of children with squint were also prescribed glasses. The Royal College of Ophthalmologists guidelines<sup>10</sup> for correction of pediatric refractive errors were followed, and prescriptions were provided if reduced vision was associated with myopia  $\geq -1$ D or with any amblyogenic refractive status. Prescriptions were also dispensed based on clinical opinion when there was reduced VA or strabismus. The types of squint most commonly found were esotropia or significant esophoria (57%), distant exotropia or significant exophoria (36.5%), and cyclo-vertical deviation (4.5%). Less detailed outcome data were available from referrals to Stepping Hill Hospital. Of 45 children attending Stepping Hill, 7 had no abnormality, 27 had refractive error and were referred to an optometrist, and 11 had some form of squint.

### Prevalence of Common Visual Problems in the Screened Cohort

Table 6 depicts the estimated prevalence of refractive error requiring glasses and estimated prevalence of

TABLE 6. Vision problems in children aged 4–5 years available for screening, North Derbyshire, UK.

	% (95%CI)
Children with prescribed glasses	9.15 (8.29–10.08)
Myopia	0.59 (0.4–0.89)
Hypermetropia	5.50 (4.48–6.26)
Astigmatic error	3.04 (2.55–3.62)
Children with manifest or significant latent squint	3.81 (3.26–4.45)
Esotropia/significant esophoria <sup>a</sup>	2.41 (1.99–2.94)
Exotropia/significant exophoria <sup>a</sup>	1.31 (1.01–1.72)
Cyclo-vertical	0.09 (0.03–0.24)

<sup>a</sup>Significant exophoria/esophoria on cover test; binocularity is broken easily into manifest squint with delayed recovery. CI, confidence interval

squint in children of reception class age (4–5 years). These data are based on calculations derived from the number of children in the referred sample found to have the condition, who failed vision screening, and who were retested in the HES (260/415; 62.7%). Diagnoses made for children already attending a HES ( $n = 121$ , Table 2) were included when estimating prevalence.

## DISCUSSION

This study provides data for benchmarking school-entry vision screening service provision in specific areas of the UK. These data, e.g. uptake rate, referral rate, diagnostic yield, false positive referral rate, and cost, provide useful information for commissioning such services for areas where primary healthcare providers are still considering the utility of having this service.

The cost of our screening service was approximately twice that reported earlier (year 2000). In a 2008 review of cost effectiveness of childhood vision screening, Carlton and co-authors<sup>11</sup> cited the average cost per screening to be £9.26 (£6.14–12.79). The greater cost of our screening service is possibly unrelated to inflation, and certainly puts into question the cost-effectiveness of such a screening model

compared to previously reported lower estimates. The average cost of a single orthoptic screening examination was €12.58 in early 2002 in Germany<sup>13</sup> and £16.06 in 2006 in Huntingdonshire (an inland county in the South-Eastern Midlands of England).<sup>12</sup> In a 2001 NHS health technology assessment, Sanderson and colleagues<sup>14</sup> estimated the mean costs of vision screening for 39–42-month-old children to be £8.51 (GP-led) and £8.81 (hospital-led), when the orthoptic vision screening was carried out along with other components of the child health check.

Although strong evidence to support vision screening programs is still lacking,<sup>15</sup> especially evidence regarding the impact of amblyopia on long-term quality of life, pre-school screening at 37 months of age is associated with improved treatment outcomes for individuals with amblyopia compared with their unscreened cohorts.<sup>16</sup> Unfortunately, the capture rate for community pre-school vision screening programs is low, averaging 64.8%.<sup>7</sup> In a retrospective review of records of participants in an orthoptist-led pre-school vision screening program in the Walsall area, UK, for the 2006–2007 school year, the capture rate was only 78%.<sup>17</sup>

It is apparent from our data that the optimal time for successful vision screening is when the child enters school. However the model still has its shortcomings. For example, despite a high screening take-up rate, nearly 7.2% of children in this study missed the screening process. Half of these children moved schools out of our catchment area. The “fail safe” action of offering screening at a HES for the other half still living in the area was not successful in our current setup due to a high non-attendance/cancellation rate (76%). Additionally, 12.5% of children referred to a HES for failing their initial screening tests also missed their HES appointments, regardless of their homes’ proximity to the hospital. We also did not have outcome data for 9.8% of referrals sent to neighboring health services.

In our study, the 11.14% referral rate from screening to a HES is higher than rates reported from primary orthoptic screening programs (4.1–10.6% of the screened population).<sup>7</sup> However, a referral rate of 14.6% from a pre-school vision screening program was recently reported by Hu and co-authors<sup>17</sup> Referral rates depend not only on the prevalence of the screened abnormality, but also on the referral criteria for targeted conditions, experience of the screener, and sensitivity of the tests used. It is recognized that orthoptist-based vision screening yield more referrals than do healthcare assistant- or GP-based programs. Additionally, the log-based linear vision test used in our screening program is considered to be the most sensitive for identifying unilateral amblyopia.<sup>18</sup>

For this screening program, we used the Sonksen LogMAR test. In this test, the lower 10th centile acuity is between 0.2 and 0.1 logMAR units for 4–5-year-olds and the inter-ocular difference is  $\leq 0.1$  logMAR in 90% of children.<sup>19</sup> Thus, there is an expected false referral rate in  $\sim 10\%$  of children who have been successfully tested. Additionally, only 97% could achieve this test for monocular linear vision, making the likelihood of false referrals to be  $>10\%$ . Accordingly, refinement of referral criteria should prove beneficial for reducing false referral rates. Such referral criteria have been adopted in our screening program, as advised by the NSC. In a school-children study using referral criteria similar to ours,<sup>20</sup> the referral rates from primary orthoptist-led screenings was 19.1%, with only 12.75% having confirmed visual defects on further orthoptic assessment. This high pass/fail rate was associated with a high false referral rate of 7% of those screened, compared to 2.64% in our study.

Our data show that more than half of referred children had refractive errors and needed glasses as the first step in management. Recruitment of optometrists by healthcare providers, whether community- or hospital-based, for the purpose of filtering out refractive errors, is likely not only to be cost-effective but also to reduce the pressure on hospital-based pediatric ophthalmology services. However, the lack of local optometrists, properly trained in pediatric refraction and willing to undertake such responsibilities, has made this endeavor so far unachievable. Moreover, the data from such a service would be scattered, making the monitoring of outcomes difficult.

From our data, it was possible to estimate the distribution of common visual problems (squint and hypermetropia) in our population-based cohort of 4–5-year-old children. Williams and colleagues<sup>21</sup> in the Avon Longitudinal Study of Parents and Children in 7-year-olds, found significant squint in 3.4% of children and hypermetropia of  $>2.0$  D in 4.8%, compared to 3.81% for squint and 5.5% for hypermetropia requiring glasses in our study. Our results are also very close to those adopted by Carlton and co-authors<sup>11</sup> (8.1% refractive error at age 5 years, compared with 9.15%) in their extensive literature review study to prepare a model for estimating the cost-effectiveness of vision screening in children.

In conclusion, our data confirm that orthoptist-led school-entry vision testing is optimal for childhood screening. Universal vision screening data from across the UK could provide valuable information to plan a successful cost-effective national screening model. Further studies on orthoptist-led school-entry childhood vision screening should be encouraged. However, the cost-effectiveness of childhood vision screening will need revisiting in the light of the ever-increasing costs associated with vision screening.

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## DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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